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A NEW RECORD FOR THE SHARK FAUNA OF THE MEDITERRANEAN SEA: WHALE SHARK, *RHINCODON TYPUS* (ORECTOLOBIFORMES: RHINCODONTIDAE)

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ABSTRACT

On October 18, 2021, a whale shark Rhincodon typus *Smith, 1828 was sighted off the coast of Samandağ (Hatay city, Turkey, NE Mediterranean Sea), by a commercial long-liner. With the addition of* R. typus*, the total number of Mediterranean shark species recorded to date has increased to 51. The changing conditions of the Mediterranean will show whether this shark will become a resident or transient species in the region.*

Key words: shark, biodiversity, planktivorous, filter feeding

NUOVA SEGNALAZIONE PER LA FAUNA DI SQUALI DEL MEDITERRANEO: SQUALO BALENA, *RHINCODON TYPUS* (ORECTOLOBIFORMES: RHINCODONTIDAE)

SINTESI

Il 18 ottobre 2021, uno squalo balena Rhincodon typus *Smith, 1828 è stato avvistato al largo della costa di Samandağ (città di Hatay, Turchia, Mediterraneo nord-orientale), da un peschereccio commerciale. Con l'aggiunta di* R. typus*, il numero totale di specie di squali del Mediterraneo registrate fino ad oggi è salito a 51. Il cambiamento delle condizioni del Mediterraneo mostrerà se questo squalo diventerà una specie residente o transitoria nella regione.*

Parole chiave: squalo, biodiversità, planctivoro, filtratore

INTRODUCTION

With the opening of the Suez Channel in 1869, the phenomenon termed "Lessepsian migration" brought about considerable changes in fish communities occurring in the eastern Mediterranean Sea (Arndt *et al.*, 2018). The tropicalization of Mediterranean waters is accelerating the establishment of tropical species, such as the whale shark *Rhincodon typus* Smith, 1828, in the Mediterranean Sea (Moschella, 2008; Turan *et al*. 2016).

The whale shark *Rhincodon typus* Smith, 1828 is the largest fish occurring in the tropical and warm temperate oceans of the world (Bonfil & Abdallah, 2004). According to Bonfil and Abdallah (2004), *R. typus* is a filter feeding shark, occurring singly or in schools, both in coastal and oceanic waters.

In the most recent checklist of elasmobranchs occurring in the Mediterranean Sea, Serena *et al*. (2020) did not mention the presence of *R. typus* in the region. In the present article, the authors report the first recording of whale shark in the Mediterranean Sea.

MATERIAL AND METHODS

On October 18, 2021, a whale shark *Rhincodon typus* Smith, 1828 (Fig. 1) was sighted off the coast of Samandağ, Hatay, Turkey, NE Mediterranen Sea (35.986045, 35.951286) (Fig. 2) by Mr. Erman Sertel, a commercial long-liner. Mr. Sertel recorded a short video footage (20 seconds) of the sighted individual and emailed the video to the first and the fourth authors in order to verify the identification of the species. Compagno (2001) was followed for taxonomic nomenclature and species identification. The recorded video is preserved in the personal archives of the first and the fourth authors, and available for inspection on request.

RESULTS AND DISCUSSION

The shark seen in the video footage and in Figure 2 has enabled us to examine the following characteristics from the dorsal perspective: head very broad and greatly flattened. Snout truncated. Gill slits very large, fifth gill slit well-separated from fourth and not overlapping. Body moderately



Fig. 1: Sighted whale shark** Rhincodon typus **Smith, 1828 off the coast of Samandağ (NE Mediterranean Sea, Turkey). Image captured from the video footage recorded by Mr. Erman Sertel.
Sl. 1: Opažen primerek morskega psa kitovca** Rhincodon typus **Smith, 1828 ob obali Samandağ (SV Sredozemsko morje, Turčija). Posnetek izvira iz videozapisa, ki ga je posnel Erman Sertel.

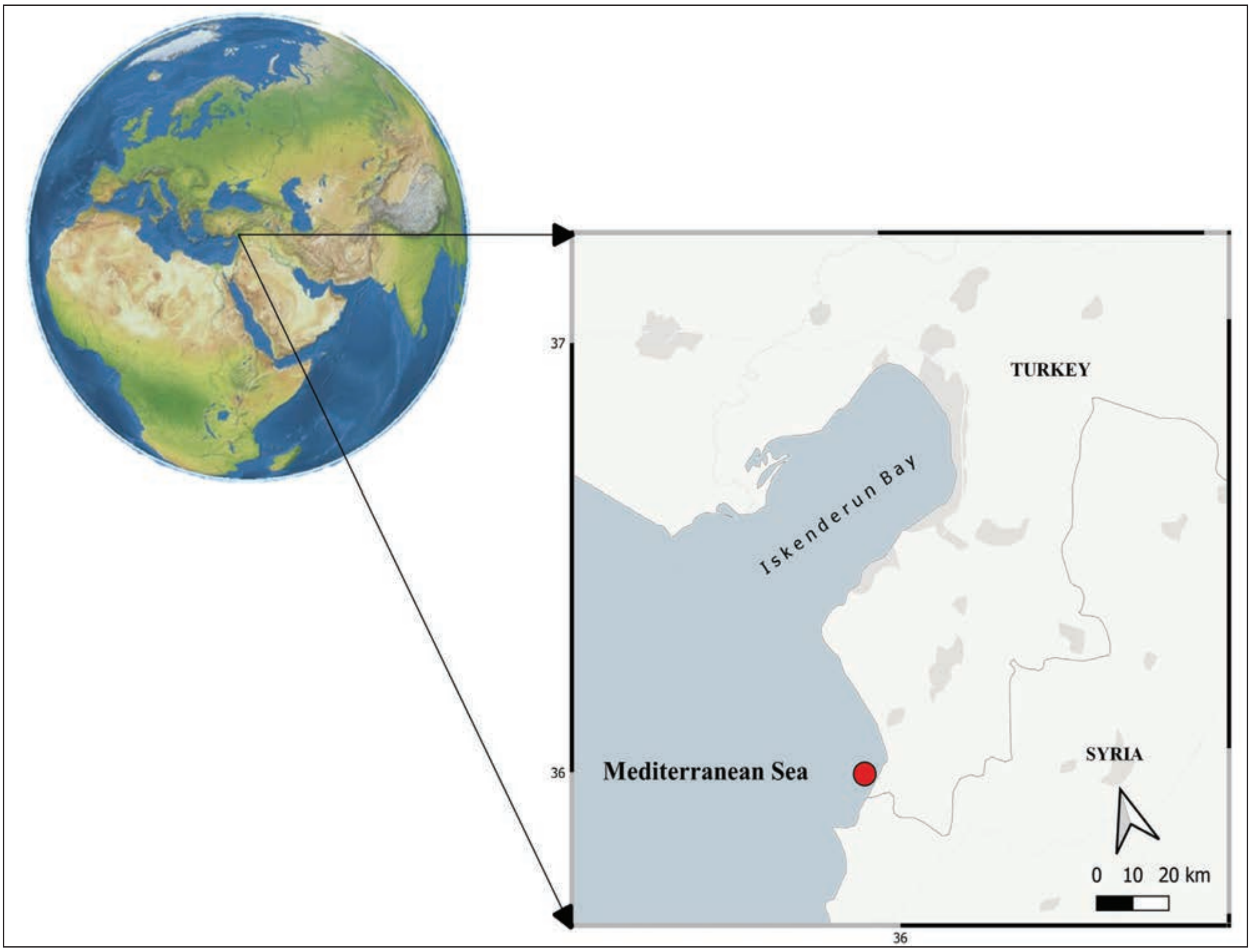


Fig. 2: The location (red circle) of the present sighting of the whale shark* Rhincodon typus *Smith, 1828 off the coast of Samandağ (NE Mediterranean Sea, Turkey).
Sl. 2: Lokacija (rdeči krogec), na kateri je bil opazovan primerek morskega psa kitovca* Rhincodon typus *Smith, 1828 ob obali Samandağ (SV Sredozemsko morje, Turčija).

depressed. Precaudal tail shorter than body. Caudal peduncle with strong lateral keels. Pectoral fins very large, relatively narrow and falcate. First dorsal fin much larger than the second. First dorsal fin origin well behind pectoral fin free rear tips. The individual exhibited the unique color pattern of *R. typus*, consisting of small to large white or yellowish spots and vertical and horizontal stripes in the form of a checkerboard on a dark background. The examined characteristics were coincident with those described by Compagno (2001); therefore, we identified the sighted shark as *Rhincodon typus* Smith, 1828.

Neither the fisherman nor the authors had a chance to measure the size of the live shark; however, based on a comparison with the fishing boat, the size of the shark was estimated by the fisherman to be roughly 300 cm.

A first mention of the possible presence of *Rhincodon typus* in the Mediterranean Sea was included in De Maddalena and Baensch (2005), who wrote: "There are unconfirmed reports of the whale shark (*Rhincodon typus*)," but the authors concluded there was no confirming evidence. And since the occurrence of *R. typus* is not mentioned in the recent checklists of marine fishes or sharks occurring in the Levantine region (Bariche, 2012; Turan *et al.*, 2018; Giovos *et al.*, 2021) or in the wider Mediterranean Sea (Serena *et al.*, 2020), the sighted individual is considered as the first record of whale shark in the Mediterranean Sea.

For the moment, the authors do not attempt to speculate on the possible reasons causing the migration of the whale shark into the Mediterranean Sea; still, every arrival of a new shark species brings new opportunities of research and new

responsibilities in terms of conservation. However, judging from its occurrence in the neighboring Red Sea waters (Bonfil & Abdallah, 2004), the present individual had apparently migrated into the eastern Levant waters through the Suez Channel. According to Pierce and Norman (2016), the whale shark is an endangered species, globally threatened by fisheries and vessel strikes. With the addition of *R. typus*, the total number of Mediterranean sharks, which was reported as 50 by De Maddalena *et al.* (2015), has increased to 51. However, the changing conditions of the Mediterranean due to climate change will show whether this shark will become a resident or transient species in the region.

ACKNOWLEDGMENTS

The Authors thank Mr. Erman Sertel, a commercial long-liner, for generously sharing the video footage of the sighted whale shark.

NOVA VRSTA V FAVNI MORSKIH PSOV SREDOZEMSKEGA MORJA: MORSKI PES KITOVEC, *RHINCODON TYPUS* (ORECTOLOBIFORMES: RHINCODONTIDAE)

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POVZETEK

Osemnajstega oktobra 2021 so s komercialnega ribiškega plovila opazovali primerek morskega psa kitovca Rhincodon typus *Smith, 1828 blizu obale Samandağ (Hatay, Turčija, SV Sredozemsko morje), Ob upoštevanju vrste* R. typus*, se je število vseh vrst morskih psov v Sredozemskem morju povečalo na 51. Spreminjajoče se razmere v Sredozemskem morju bodo pokazale ali bo ta vrsta morskih psov postala ustaljena vrsta ali pa gre le za prehodno vrsto v bazenu.*

Ključne vrste: morski psi, biodiverziteta, planktivori, prehranjevanje s filtriranjem

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NEW EVIDENCE OF THE ONGOING EXPANSION OF *OKENIA PICOENSIS* PAZ-SEDANO, ORTIGOSA & POLA, 2017 (GASTROPODA: NUDIBRANCHIA) IN THE CENTRAL-EASTERN MEDITERRANEAN

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ABSTRACT

The present note reports new findings of the nudibranch Okenia picoensis *in the Mediterranean Sea. This species was described from Pico Island (Azores, Atlantic Ocean) in 2017, and subsequently, in the last few years, it has been reported in some areas of the Mediterranean Sea. Hereby, we document new records of* O. picoensis*, reported between March and May 2021 along the central-eastern coast of Sicily (Ionian Sea) which could suggest a possible establishment of the species in this area.*

Key words: Goniodorididae, Heterobranchia, Ionian Sea, Mollusca, new reports

NUOVE PROVE DELLA CONTINUA ESPANSIONE DI *OKENIA PICOENSIS* PAZ-SEDANO, ORTIGOSA & POLA, 2017 (GASTROPODA: NUDIBRANCHIA) NEL MEDITERRANEO CENTRO-ORIENTALE

SINTESI

La presente nota riporta alcuni nuovi ritrovamenti nel Mediterraneo del nudibranco Okenia picoensis*. Questa specie è stata descritta nel 2017 per l'Isola di Pico (Azzorre, Oceano Atlantico) e, successivamente, durante gli ultimi anni è stata riportata in alcune aree del Mediterraneo. Con la presente, documentiamo nuove segnalazioni di* O. picoensis*, avvenute tra marzo e maggio 2021 lungo la costa centro-orientale della Sicilia (Mar Ionio), che potrebbero indicare un possibile insediamento di questa specie in quest'area.*

Parole chiave: Goniodorididae, Heterobranchia, mar Ionio, Mollusca, nuove segnalazioni

INTRODUCTION

Until recently, the genus *Okenia* Menke, 1830 (Nudibranchia Goniodorididae) consisted of six species inhabiting the Mediterranean Sea, namely *O. aspersa* (Alder & Hancock, 1845), *O. elegans* (Leuckart, 1828), *O. hispanica* Valdés & Ortea, 1995, *O. mediterranea* (Ihering, 1886), *O. longiductis* Pola, Paz-Sedano, Macali, Minchin, Marchini, Vitale, Licchelli & Crocetta, 2019, and *O. problematica* Pola, Paz-Sedano, Macali, Minchin, Marchini, Vitale, Licchelli & Crocetta, 2019 (Pola *et al.*, 2019). However, between 2020 and 2021, another species of the genus, *O. picoensis* Paz-Sedano, Ortigosa & Pola, 2017, was recorded for the first time in the basin (Orfanidis *et al.*, 2021; Crocetta *et al.*, 2021). This species was originally described from Pico Island (Azores, Portugal, Atlantic Ocean) (Paz-Sedano *et al.*, 2017). At morphological level, *O. picoensis* presents a mantle covered by spicules and the edge of the notum with five lateral papillae, symmetrically distributed on each side of the body. The papillae are usually distributed as follows: the two anteriormost are in front of the rhinophores, the two posteriormost, which are the longest, are behind the gills, and along each side of the notum, between the rhinophores and the gills, there are three lateral papillae. Moreover, there is also a single dorsal papilla, which originates from an evident ridge located between the rhinophores and the gills. The rhinophores present from seven to nine lamellae, while the gills are four and of similar shape as the papillae (Paz-Sedano *et al.*, 2017).

Tab. 1: Reports of** Okenia picoensis **in the Mediterranean Sea.
Tab. 1: Lokalitete, kjer je bila vrsta** Okenia picoensis **potrjena v Sredozemskem morju.

Date	Location	Number of specimens	Depth (m)	Temperature (°C)	References
6 Nov. 2020	Ċirkewwa, Malta	unknown	29	21	Orfanidis *et al.* (2021)
18 Nov. 2020	Wied iż-Żurrieq, Malta	unknown	23	21	Orfanidis *et al.* (2021)
24 Nov. 2020	Ċirkewwa arch, Malta	unknown	17	21	Orfanidis *et al.* (2021)
17 Jan. 2021	Wied iż-Żurrieq, Malta	unknown	27	16	Orfanidis *et al.* (2021)
1 March 2021	Granada, Spain	1	16	15	Orfanidis *et al.* (2021)
6 March 2021	Acque Fredde, Italy	1	21.9	14	Crocetta *et al.* (2021)
14 March 2021	Ognina, Italy	1	21.2	14	Present study (Fig. 2A)
18 March 2021	Scalo Pennisi, Italy	2	14.9 – 21.4	14	Present study (Fig. 2B, C)
27 March 2021	Santa Maria La Scala, Italy	1	20	14	Present study (Fig. 2D)
1 May 2021	Bellatrix, Italy	1	15.9	16	Present study (Fig. 2E)
4 May 2021	Scalo Pennisi, Italy	3	15 – 22.3	15	Present study (Fig. 2F, G, H)

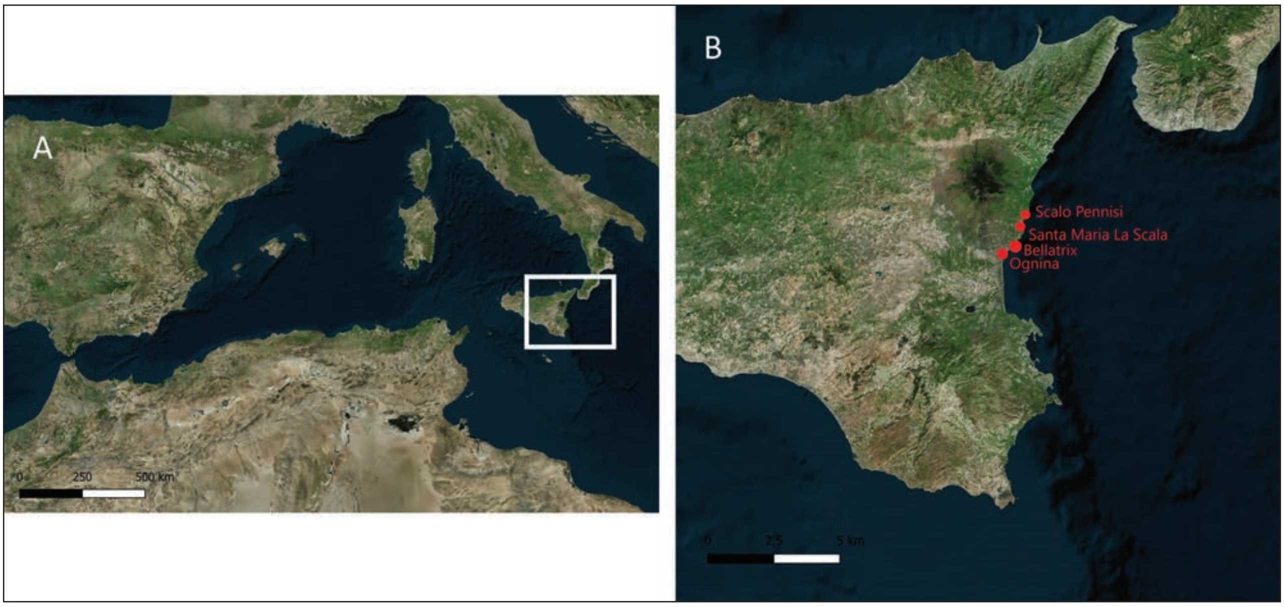


Fig. 1: A) Geographical location of the study area. B) Detail of the study areas (Scalo Pennisi, Santa Maria La Scala, Bellatrix, Ognina) where specimens of** Okenia picoensis **were found.
Sl. 1: A) Geografski položaj raziskanega območja. B) Detajli raziskanih predelov (Scalo Pennisi, Santa Maria La Scala, Bellatrix, Ognina), kjer so bili najdeni primerki vrste** Okenia picoensis**.

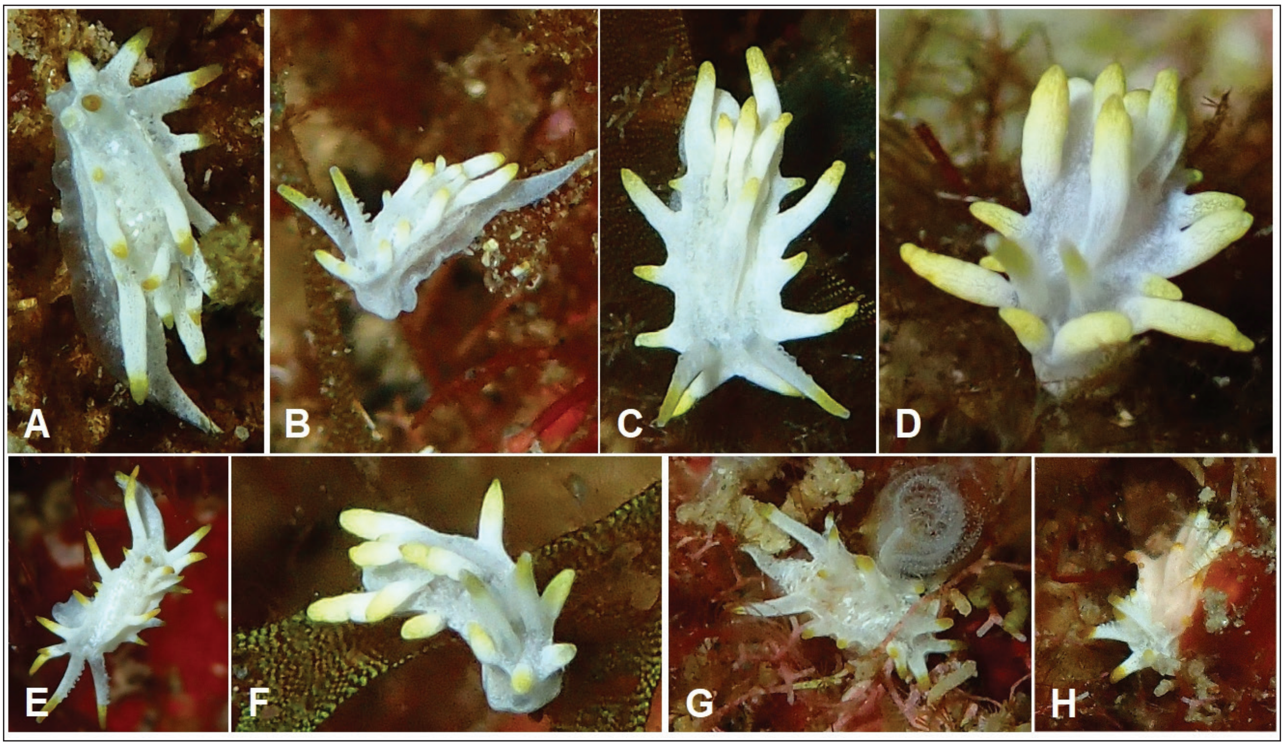


Fig. 2: The eight specimens of* Okenia picoensis *found along the central-eastern coast of Sicily (Italy). A) The specimen found in Ognina (Photo by A. Lombardo); B) The first specimen seen in Scalo Pennisi (Photo by A. Lombardo); C) The second specimen from Scalo Pennisi (Photo by A. Lombardo); D) The specimen observed in Santa Maria La Scala (Photo by G. Marletta); E) The specimen found in Bellatrix (Photo by A. Lombardo); F) The third specimen found in Scalo Pennisi (Photo by A. Lombardo); G) The fourth specimen from Scalo Pennisi (Photo by A. Lombardo); H) The fifth specimen from Scalo Pennisi (Photos by A. Lombardo).
Sl. 2: Osem primerkov vrste* Okenia picoensis*, najdenih vzdolž srednje vzhodne obale Sicilije (Italija). A) Primerek najden na lokaliteti Ognina (Foto: A. Lombardo); B) Prvi primerek, opažen na lokaliteti Scalo Pennisi (Foto: A. Lombardo); C) Drugi primerek, opažen na lokaliteti Scalo Pennisi (Foto: A. Lombardo); D) Primerek, opažen na lokaliteti Santa Maria La Scala (Foto: G. Marletta); E) Primerek, najden na lokaliteti Bellatrix (Foto: A. Lombardo); F) Tretji primerek, opažen na lokaliteti Scalo Pennisi (Foto: A. Lombardo), G) Četrti primerek, opažen na lokaliteti Scalo Pennisi (Foto: A. Lombardo), H) Peti primerek, opažen na lokaliteti Scalo Pennisi (Foto: A. Lombardo).

This species displays two different chromatic patterns (Paz-Sedano *et al.*, 2017; Orfanidis *et al.*, 2021): one with a bright yellow body and orange-tipped papillae, and one with a white body and yellow-tipped papillae.

Since its first finding in the Azores, this species seems to have appeared suddenly and almost simultaneously in several areas of the Mediterranean: it was recorded four times in Malta in November 2020 and January 2021 (Orfanidis *et al.*, 2021), and then twice in March 2021, once in Granada (Spain) and once in Santa Tecla (Italy) (Orfanidis *et al.*, 2021; Crocetta *et al.*, 2021) (Tab. 1).

This short note reports eight new records of *O. picoensis* from the central-eastern coast of Sicily (Ionian Sea, Italy) and discusses the species' spread and possible ways of entering the Mediterranean Sea.

MATERIAL AND METHODS

Scuba diving observations of *O. picoensis* specimens were carried out in four areas located along the central-eastern coast of Sicily (Fig. 1A, B): Ognina (37°31′50.4″N – 15°07′10.8″E) and Bellatrix (37°32′03.2″N – 15°07′35.2″E), located in the municipality of Catania, and Scalo Pennisi (37°38′23.2″N – 15°11′04.6″E) and Santa Maria La Scala (37°36′46.5″N – 15°10′31.4″E), located in the municipality of Acireale.

The specimens of *O. picoensis* were identified *in vivo* and photographed with underwater cameras Olympus TG-4 and Olympus TG-6. During the scuba dives (carried out between 9 and 11:30 a.m.), the depth and the substrates, where the specimens were encountered, and their activities during the spotting were annotated.

RESULTS

Throughout March and May 2021, a total of eight specimens were observed in the examined areas (Fig. 2). The specimens were detected in a range of depth of 14.9 – 21.4 m on rocky bottoms covered by photophilous seaweeds. Specifically, one individual was found on a thallus of a *Halopteris filicina* (Grateloup) Kützing, one specimen was detected on a filamentous red alga, two specimens were spotted on thalli of *Dictyota dichotoma* (Hudson) J. V. Lamouroux, two individuals were observed embedded in a filamentous tangle of brown and red seaweeds covered by detritus, and two specimens were found on a small rocky wall covered by a turf of red algae and tunicates.

Most of the specimens presented a couple of papillae in front of the rhinophores, three papillae on each side of the notum and a couple of papillae (the most elongated) behind the gills. There was also a dorsal papilla in front of the gills and the rhinophores had from six to nine lamellae. Nevertheless, two individuals, one found in Scalo Pennisi (Fig. 2C) and one found in Bellatrix (Fig. 2E), displayed a higher number of papillae bordering the notum: 12 and 14, respectively. Moreover, a specimen observed in Scalo Pennisi displayed a different organization of the papillae (Fig. 2F). Indeed, although the specimen had two anteriormost and two posteriormost papillae, like the other specimens, it presented only two lateral papillae on each side of the notum.

Finally, two individuals observed in Scalo Pennisi (Fig. 2G, H) were found sited near each other and, in one of them, it was possible to count the papillae: two were in front of the rhinophores, three on each side of the notum, and two most elongated ones behind the gills. Overall, all the found specimens exhibited a white chromatic pattern with yellow-tipped papillae.

DISCUSSION

Considering that the origin of distribution of *O. picoensis* is in the Azores, it is probable for this species to have entered the Mediterranean through the Gibraltar Strait. Indeed, this species likely arrived to the Mediterranean basin during the veliger stage through an anthropogenic vector (e.g., ballast waters, attached to ships' keels) or through natural dispersal (e.g., currents). In recent years, three other species of Nudipleura, two originally described in the Macaronesia and one distributed in this region, have been found along the central-eastern coast of Sicily: *Pleurobranchus wirtzi* Ortea, Moro & Caballer, 2014, *Taringa tritorquis* Ortea, Perez & Llera, 1982 (Lombardo & Marletta, 2019; 2020a; Gerovasileiou *et al.*, 2020), and *Aporodoris millegrana* (Alder & Hancock, 1854) (Lombardo & Marletta, 2020b). Therefore, the occurrence of *O. picoensis* in this area could strengthen the evidence that in the last decade, the barriers to dispersal which prevented the spread of some Atlantic species into the Mediterranean (the Canary Current, Saharan upwelling, and the Almería-Oran Front) experienced a weakening, probably due to the global climatic change (Valdés *et al.*, 2013).

In the Mediterranean, *O. picoensis* was suddenly and for a brief period (November 2020–May 2021), observed in several areas located far apart (south Spain and Malta/Sicily). Therefore, as suggested for *Aplysia dactylomela* Rang, 1828 (Valdés *et al.*, 2013), this species was probably transported as veliger by the powerful Algerian Current, which took it directly into the Central Mediterranean; there the sub-basin scale gyre eddies associated with the Algerian Current transferred these pelagic larvae into the Sicily Channel, where the Mid-Mediterranean Jet rapidly splits into two main branches affecting the North African coast and southern Sicily. This hydrodynamic pattern could thus explain why this species was found both in Malta and along the central-eastern coast of Sicily. Regarding the latter area, the finding of several specimens during March and May (Crocetta *et al.*, 2021; present study), indicate that *O. picoensis* may have found favourable conditions for its growth and development. Indeed, the wide thermal range in which this species was found (from 14 to 21°C) (Orfanidis et al., 2021; Crocetta *et al.*, 2021; present work) might be indicative of a high level of adaptability of this nudibranch to temperature. Consequently, it is likely that in the near future this species could easily establish and settle in this and other areas of Mediterranean.

Regarding the ecology of the species, the information in both its native and expanded range of distribution is incomplete. In fact, the observations on *O. picoensis* only concern its seasonality and bathymetric range. In its native area, this nudibranch was found in June and November, between 8 and 30 m of depth (Paz-Sedano *et al.*, 2017), while in the Mediterranean, it was observed in November, January, March, and May, between 14.9 and 29 m of depth (Orfanidis *et al.*, 2021; Crocetta *et al.*, 2021; present work). Furthermore, differently from its native area, where both *O. picoensis* chromatic patterns were seen, in the Mediterranean only the white morph has hitherto been found. In addition, through the present study it has been observed that the number of lateral papillae in *O. picoensis* can probably vary according to the size of the animal and does not seem to be constant as instead reported by Paz-Sedano *et al.* (2017).

In conclusion, the finding of this nudibranch in the Mediterranean Sea may be further proof of how the seawater of this Basin is experiencing a warming trend. Furthermore, in the central-eastern coast of Sicily, only two species belonging to the genus *Okenia* – *O. problematica* and *O. longiductis* – had been previously reported by Lombardo and Marletta (2020b; 2020c; 2021). Considering that in this area these latter species seem to be rare, and with no other relatives to this genus, O. *picoensis*, which is probably more competitive, might easily establish in the local marine communities, successfully reproduce, and spread elsewhere.

NOVI PODATKI O ŠIRJENJU AREALA VRSTE *OKENIA PICOENSIS* PAZ-SEDANO, ORTIGOSA & POLA, 2017 (GASTROPODA: NUDIBRANCHIA) V SREDNJEM VZHODNEM SREDOZEMSKEM MORJU

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POVZETEK

V prispevku avtorja poročata o novih najdbah vrste gološkrgarja Okenia picoensis *v Sredozemskem morju. To vrsto so opisali z otoka Pico (Azori, Atlantski ocean) v 2017, naknadno, v naslednjih nekaj letih, pa so o njej poročali v nekaterih predelih Sredozemskega morja. Avtorja sta med marcem in majem 2021 zbrala podatke o novih najdbah vrste* O. picoensis *vzdolž srednje vzhodne obale Sicilije (Jonsko morje), ki kažejo na možno ustalitev vrste na tem območju.*

Ključne besede: Goniodorididae, Heterobranchia, Jonsko morje, Mollusca, novi zapisi

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SREDOZEMSKI MORSKI PSI

SQUALI MEDITERRANEI

MEDITERRANEAN SHARKS

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A REVIEW OF SHARK BIODIVERSITY IN TURKISH WATERS: UPDATED INVENTORY, NEW ARRIVALS, QUESTIONABLE SPECIES, AND CONSERVATION ISSUES

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ABSTRACT

Available data reveal that the current shark fauna of the Turkish waters includes 37 confirmed species: Hexanchus griseus, Heptranchias perlo, Echinorhinus brucus, Squalus acanthias, S. blainvillei, Centrophorus *cf.* uyato, Etmopterus spinax, Somniosus rostratus, Oxynotus centrina, Dalatias licha, Squatina aculeata, S. oculata, S. squatina, Carcharias taurus, Odontaspis ferox, Alopias superciliosus, A. vulpinus, Cetorhinus maximus, Carcharodon carcharias, Isurus oxyrinchus, Lamna nasus, Galeus melastomus, Scyliorhinus canicula, S. stellaris, Galeorhinus galeus, Mustelus asterias, M. mustelus, M. punctulatus, Carcharhinus altimus, C. brachyurus, C. brevipinna, C. falciformis, C. limbatus, C. obscurus, C. plumbeus, Prionace glauca, *and* Sphyrna zygaena. *Based on current information, the most significant threat to sharks in Turkish waters is the adverse impact of bycatch.*

Key words: Elasmobranchii, inventory, state of art, Turkey

REVISIONE DELLA BIODIVERSITÀ DEGLI SQUALI IN ACQUE TURCHE: INVENTARIO AGGIORNATO, NUOVI ARRIVI, SPECIE DISCUTIBILI E PROBLEMI DI CONSERVAZIONE

SINTESI

I dati disponibili rivelano che l'attuale fauna di squali delle acque turche comprende 37 specie confermate: Hexanchus griseus, Heptranchias perlo, Echinorhinus brucus, Squalus acanthias, S. blainvillei, Centrophorus *cf.* uyato, Etmopterus spinax, Somniosus rostratus, Oxynotus centrina, Dalatias licha, Squatina aculeata, S. oculata, S. squatina, Carcharias taurus, Odontaspis ferox, Alopias superciliosus, A. vulpinus, Cetorhinus maximus, Carcharodon carcharias, Isurus oxyrinchus, Lamna nasus, Galeus melastomus, Scyliorhinus canicula, S. stellaris, Galeorhinus galeus, Mustelus asterias, M. mustelus, M. punctulatus, Carcharhinus altimus, C. brachyurus, C. brevipinna, C. falciformis, C. limbatus, C. obscurus, C. plumbeus, Prionace glauca, *e* Sphyrna zygaena. *Sulla base delle informazioni attuali, la minaccia più significativa per gli squali nelle acque turche è l'impatto negativo della cattura accidentale.*

Parole chiave: Elasmobranchii, inventario, stato dell'arte, Turchia

INTRODUCTION

Historically, the willingness or priority to study shark species occurring in Turkish waters was remarkably low, like in the rest of the world (Camhi *et al.*, 1998). In terms of timeline, we can say that the first efforts to record sharks living in Turkish waters started with a great white shark (*Carcharodon carcharias*) that was landed in the Bosphorus in February 1881 (Kabasakal, 2020a). Following this first case, several pioneering lists of shark species living in Turkish waters have been published by various researchers (*e.g.*, Ninni, 1923; Deveciyan, 1926; Ayaşlı, 1937; Erazi, 1942; Akşıray, 1987), but they represent only a small part of the general ichthyology inventories. Nevertheless, these historical publications are a valuable treasure of information about the status of shark species that used to occur in Turkish seas.

Over the past three decades, we have witnessed a remarkable increase in the quality and quantity of studies on shark species occurring in Turkish seas (Kabasakal, 2019a). The shark species in question display considerable diversity in terms of habitat (coastal or open sea species, deep or middle water species, shallow or deep sea species), feeding strategy (large predators, planktivores, etc.), and maximum size (Kabasakal, 2020b). Nowadays, social media-based shark communication (i.e., shark capture or sightings) and internet media, the use of which has become widespread in recent years, as well as field research, have a large share in uncovering this rich shark biodiversity (Kabasakal *et al.*, 2017; Bengil, 2020; Kabasakal & Bilecenoğlu, 2020). Thanks to this intense information flow, new data are being added to what is already known about shark biodiversity in Turkey. In this review article, which evaluates shark biodiversity in Turkish waters, the author discusses the status of the species that have been confirmed or are considered questionable in the region, as well as the issues related to conservation, in the light of current information.

MATERIAL AND METHODS

Sampling methodology

Since 54 percent of Mediterranean sharks are at a high risk of extinction (Dulvy *et al.*, 2016), the current study is a typical instance of opportunistic sampling using internet data sources such as fishing blogs (Jessup, 2003). The websites of local and national newspapers and social media platforms were regularly scanned for the years 2006–2020. Since online communities and website administrators may react negatively to the use of their online content by researchers, all internet content scraping activity was carried out responsibly in order not to compromise any personal data or images, following the recommended ethical guidelines (Monkman *et al.*, 2017). To extract data from electronic sources, a Boolean search was conducted in search engines, such as Google Scholar, ScienceDirect etc., with the following keywords: "sharks," "elasmobranchi," "Turkey," "Levantine," "Black, Marmara, Aegean OR Mediterranean seas," "distribution," "hexanchiformes," "lamniformes," "squaliformes," "carcharhiniformes." The aforementioned internet search was also carried out with the French and Italian equivalents of the relevant keywords. A manual search was made to extract data published in pre-2000 journals that were not accessible via internet.

Study region

Turkey is a peninsular country surrounded by the Black Sea, Aegean and Levant Seas, and the Turkish Straits System (TSS), which runs along the Çanakkale Strait, Marmara Sea, and the Istanbul Strait. In general, the following points about the oceanographic characteristics of the seas around Turkey stand out: The high concentration of hydrogen sulfide in the Black Sea below 150 to 200 m is an important factor that prevents fish from dispersing in deep regions (Prodanov *et al.*, 1997). According to Öztürk & Öztürk (1996), TSS plays an important and determinant ecological role in the distribution of living organisms between the Mediterranean and the Black Sea, as it creates a barrier, corridor or acclimatization zone for marine species. The Aegean Sea is topographically (at approximately 38° latitude) divided into two basins, the northern and southern Aegean (Papaconstantinou, 1992). Papaconstantinou (1987) defined the north Aegean Sea as an area of cold water fauna and the south Aegean Sea as a warm water fauna sea containing Lessepsian immigrants. Finally, with the opening of the Suez Canal in 1869 and the general warming of the world's oceans, the Mediterranean has been affected by a phenomenon known as "tropicalization," which causes temperate species to retreat to colder regions (Bianchi & Morri 2003).

Taxonomic nomenclature and status of species

Occurrence statuses of sharks present in Turkish seas are adopted from definitions proposed by Vas (1991). The sharks included in this review can be grouped in 3 categories based on their relative occurrence in Turkish waters: Residents (R) - specimens of these species can be found in Turkish waters all the year round; Seasonals (S) - these species occur in Turkish waters for part of the year only as a result of seasonal migrations; and Vagrants (V) - these species

occur rarely or infrequently in Turkish waters, usually as solitary specimens. The taxonomic classification of orders, families and species, and nomenclature are based on Serena *et al*. (2020).

RESULTS AND DISCUSSION

Shark biodiversity in Turkish seas

Altogether 38 shark species are reported for Turkish waters based on the current species lists (Kabasakal, 2020b; Kabasakal & Bilecenoğlu, 2020). The reason why previous lists mentioned 38 species is that *Centrophorus granulosus* was accepted as a valid species. However, Serena *et al*. (2020) stated that the Mediterranean species of the genus *Centrophorus* are still controversial and currently only one species, *Centrophorus* cf. *uyato*, occurs in the region. Based on the conclusions of Serena *et al*. (2020), the occurrence of *C. granulosus* in Turkish waters is questionable. Therefore, this species has been removed from the list compiled in the current review. In this same study, the presence of *Carcharhinus melanopterus* in the Mediterranean Sea is also considered questionable. Although not included in the species list presented in Kabasakal (2020b), Irmak & Özden (2021) have recently reported the presence of *Somniosus rostratus* in Turkish waters. Based on this new information, the current number of shark species occurring in Turkish seas has been corrected to 37 (Tab. 1). These species are represented by 5 orders and 18 families (Kabasakal, 2020b). This figure, which corresponds to 77 percent of the currently confirmed species number in the Mediterranean (n=48; Serena *et al*., 2020), reveals that there is a remarkable shark biodiversity in Turkish seas when evaluated on a Mediterranean basis. The taxonomic status, common names, occurrence status, and distribution of these species are presented in Table 1.

On the basis of their relative occurrence, approximately 42% of the species consist of vagrant and 42% of resident species, followed by seasonal sharks of approximately 17% (Table 1). Considering the distribution of sharks in Turkish seas, all species (100%) occur in the Mediterranean Sea, 83% of them in the Aegean Sea, about 47% in the Marmara Sea, and about 22% in the Black Sea (Table 1). Sharks of the order Carcharhiniformes are represented in Turkish seas with the largest number of species (4 families, 16 species, about 44% of the total species), followed by Lamniformes (4 families, 8 species, about 22% of the total species), Squaliformes (7 families, 8 species, about 19% of the total species), Squatiniformes (1 family, 3 species, about 10% of the total species) and Hexanchiformes (1 family, 2 species, about 6% of the total species).

Order Hexanchiformes

Family Hexanchidae Gray, 1851

The family Hexanchidae is represented in Turkish seas by 2 species. *Hexanchus griseus* (Bonnaterre, 1788) is distributed throughout the Turkish seas, while *Heptranchias perlo* (Bonnaterre, 1788) displays sporadic and seldom occurrences in Aegean and Mediterranean waters (Kabasakal, 2020b; Erguden & Bayhan, 2015a). The earliest records of hexanchid sharks, *H. griseus* and *H. perlo,* in Turkish waters were reported in general ichthyological inventories by Ninni (1923), Deveciyan (1926) and Akşıraş (1987); however, their contemporary occurrences in the mentioned marine region were confirmed by Kabasakal & İnce (2008), Kabasakal (2013a), Başusta (2015), Ayas *et al*. (2018) and Bayhan *et al*. (2018). Among these, studies by Kabasakal (2013a) and Başusta (2015) are certainly worth mentioning. On 19 November 2004, one male specimen of *H. griseus* of 300 cm TL, weighing 250 kg was captured by a commercial gill-netter nearly 3 miles off the coast of Amasra, and this single capture extends the Mediterranean distribution of *H. griseus* to the Black Sea (Kabasakal, 2013a). Recent reviews of large sharks caught by commercial fisheries in Turkish waters have shown that *H. griseus* is the predominant species, accounting for 43.2% (169 out of 392 specimens; Kabasakal *et al*., 2017) and 51.8% (139 out of 268 specimens; Kabasakal & Bilecenoğlu, 2020) of total captures.

Order Lamniformes

Family Odontaspididae Müller and Henle, 1839

The family Odontaspididae is represented in Turkish seas with 2 species: *Carcharhias taurus* Rafinesque, 1810 and *Odontaspis ferox* (Risso, 1810). In an earlier report, *C. taurus* was reported from Saroz Bay (NE Aegean Sea) by Cengiz *et al*., (2011). Occurrence of *O. ferox* in Turkish waters has always been a matter of discussion. In a previous review of elasmobranch species inhabiting Turkish waters, Kabasakal (2002) included *O. ferox* in the inventory of sharks of Turkey, based on the list of Turkish marine fishes provided by Mater and Meriç (1996); however, the presence of this species in the mentioned area remained unconfirmed, until Fergusson *et al*. (2008) reported on the occurrence of three smalltooth sand tiger sharks in Turkish Aegean waters. Recently, a female specimen of *O. ferox* (400 cm TL) has been incidentally captured in Antalya Bay by a commercial otter-trawler (Kabasakal & Bayrı, 2019).

Tab. 1: Checklist of sharks in Turkish waters. R: Resident; V: Vagrant; S: Seasonal; BS: Black Sea; SM: Sea of Marmara; AS: Aegean Sea; MS: Mediterranean Sea. Occurrence statuses (R, V, S) of sharks are adopted from the definitions proposed by Vas (1991), with explanations of these definitions given in the Material and Methods section. Taxonomic classification of orders, families, and species is based on Serena** et al. **(2020).

Tab. 1: Seznam vrst morskih psov v turških morjih. R: Rezidentna vrsta; V: Klatež; S: Sezonska vrsta; BS: Črno morje; SM: Marmarsko morje; AS: Egejsko morje; MS: Sredozemsko morje. Status pojavljanja (R, V, S) vrst morskih psov je bil privzet iz definicij, ki jih je predlagal Vas (1991), s pojasnili, ki jih navajamo v poglavju Material in metode. Taksonomska klasifikacija v smislu redov, družin in vrst temelji na delu Serena** et al. **(2020).

Order HEXANCHIFORMES	Common name	Occurrence status	Distribution in the region
Family Hexanchidae			
Heptranchias perlo (Bonnaterre, 1788)	sharpnose seven-gill shark	V	AS, MS
Hexanchus griseus (Bonnaterre, 1788)	bluntnose six-gill shark	R	BS, SM, AE, MS
Order SQUALIFORMES			
Family Echinorhinidae			
Echinorhinus brucus (Bonnaterre, 1788)	bramble shark	V	SM, AE, MS
Family Squalidae			
Squalus acanthias Linnaeus, 1758	spotted spiny dogfish	R	BS, SM, AE, MS
Squalus blainvillei (Risso, 1827)	longnose spurdog	R	BS, SM, AE, MS
Family Centrophoridae			
Centrophorus cf. uyato (Rafinesque, 1810)	little gulper shark	V	SM, AE, MS
Family Etmopteridae			
Etmopterus spinax (Linnaeus, 1758)	velvet belly	R	AE, MS
Family Somniosidae			
Somniosus rostratus (Risso, 1827)	little sleeper shark	R	MS
Family Oxynotidae			
Oxynotus centrina (Linnaeus, 1758)	angular rough shark	R	SM, AE, MS
Family Dalatiidae			
Dalatias licha (Bonnaterre, 1788)	kitefin shark	V	SM, AE, MS
Order SQUATINIFORMES			
Family Squatinidae			
Squatina aculeata Cuvier, 1829	sawback angelshark	R	AE, MS
Squatina oculata Bonaparte, 1840	smoothback angelshark	R	SM, AE, MS
Squatina squatina (Linnaeus, 1758)	angelshark	R	BS, SM, AE, MS
Order LAMNIFORMES			
Family Odontaspididae			
Carcharias taurus Rafinesque, 1810	sandtiger shark	V	AE, MS
Odontaspis ferox (Risso, 1810)	smalltooth sand tiger	V	AE, MS
Family Alopiidae			
Alopias superciliosus Lowe, 1841	bigeye thresher	S	SM, AE, MS
Alopias vulpinus (Bonnaterre, 1788)	thresher shark	R	BS, SM, AE, MS
Family Cetorhinidae			
Cetorhinus maximus (Gunnerus, 1765)	basking shark	S	AE, MS
Family Lamnidae			
Carcharodon carcharias (Linnaeus, 1758)	great white shark	S	AE, MS
Isurus oxyrinchus Rafinesque, 1810	shortfin mako	S	AE, MS
Lamna nasus (Bonnaterre, 1788)	porbeagle	V	SM, AE, MS
Order CARCHARHINIFORMES			
Family Pentanchidae			
Galeus melastomus Rafinesque, 1810	blackmouth catshark	R	SM, AE, MS
Family Scyliorhinidae			
Scyliorhinus canicula (Linnaeus, 1758)	smallspotted catshark	R	BS, SM, AE, MS
Scyliorhinus stellaris (Linnaeus, 1758)	nursehound	R	SM, AE, MS
Family Triakidae			
Galeorhinus galeus (Linnaeus, 1758)	tope shark	V	AE, MS
Mustelus asterias Cloquet, 1819	starry smoothhound	R	BS, SM, AE, MS
Mustelus mustelus (Linnaeus, 1758)	smoothhound	R	BS, SM, AE, MS
Mustelus punctulatus Risso, 1827	blackspotted smoothhound	R	AE, MS
Family Carcharhinidae			
Carcharhinus altimus (Springer, 1950)	bignose shark	V	MS
Carcharhinus brachyurus (Günther, 1870)	copper shark	V	MS
Carcharhinus brevipinna (Valenciennes, 1839)	spinner shark	V	AE, MS
Carcharhinus falciformis (Bibron, 1839)	silky shark	V	MS
Carcharhinus limbatus (Valenciennes, 1839)	blacktip shark	V	MS
Carcharhinus obscurus (Lesueur, 1818)	dusky shark	V	MS
Carcharhinus plumbeus (Nardo, 1827)	sandbar shark	S	AE, MS
Prionace glauca (Linnaeus, 1758)	blue shark	S	AE, MS
Family Sphyrnidae			
Sphyrna zygaena (Linnaeus, 1758)	smooth hammerhead	V	AE, MS

Family Lamnidae Bonaparte, 1835

The family Lamnidae is represented in Turkish seas with 3 species: *Carcharodon carcharias* (Linnaeus, 1758), *Isurus oxyrinchus* Rafinesque, 1810, and *Lamna nasus* (Bonnaterre, 1788). Historically, *C. carcharias* was listed in general ichthyological inventories of Turkish waters (Deveciyan, 1926; Ayaşlı, 1937; Akşıray, 1987). A detailed search in the archives of newspapers published between the early 1900s and late 1960s, revealed several specimens of *C. carcharias* incidentally captured by tuna hand-liners in the Istanbul Strait during the mentioned period (Kabasakal, 2003). Further research has revealed contemporary presence of *C. carcharias* in Turkish Aegean waters (Kabasakal & Gedikoğlu, 2008; Kabasakal *et al*., 2009 Kabasakal, 2014; Kabasakal & Kabasakal, 2015). Although available data suggest that *C. carcharias* is an extant lamnoid shark off the Turkish coast of the Aegean Sea, although currently not occurring in the Sea of Marmara (Kabasakal, 2020a), recently a young-of-the-year specimen has been incidentally captured in the southern entrance to the Dardanelles Strait, which might be a sign that the species is starting to recolonise its former habitat in the vicinity of the Sea of Marmara (Kabasakal & Bayrı, 2020).

Recent studies confirm the contemporary occurrence of *I. oxyrinchus* in Turkish Aegean and Mediterranean waters (Ergüden *et al*., 2013, 2021; Kabasakal & Kabasakal, 2013; Kabasakal, 2015a, Tunçer & Kabasakal, 2016; Kabasakal, 2017b). According to Kabasakal *et al*. (2017), *I. oxyrinchus* accounted for 5.3% of the total catch of large sharks captured by commercial fishermen during the 1990–2015 period, in Turkish waters. Occurrence of the porbeagle shark, *Lamna nasus*, in Turkish waters was reported by Deveciyan (1926), Akşıray (1987), and Kabasakal (2002). Kabasakal & Kabasakal (2004) reported on a porbeagle shark, 250 cm TL, caught off Bozcaada (northern Aegean Sea) on 11 April 2004. *L. nasus* is a rare shark in Turkish waters, and its questionable presence in Marmaric waters requires confirmation (Kabasakal & Karhan, 2015).

Family Cetorhinidae Gill, 1861

Occurrence data of *Cetorhinus maximus* (Gunnerus, 1765) in Turkish waters date back to the 1990s and consist of an anecdotal record of basking shark in northeastern Levantine waters (Kıdeyş, 1997), and further records of basking sharks off Turkish coasts, particularly in the Bay of Antalya (Kabasakal, 2013b) and Gulf of Mersin (Ergüden *et al.,* 2020a). In a recent review of the status of basking shark in the eastern Mediterranean based on an extremely low number of records off Turkish coast during the 1950s, Kabasakal (2013b) emphasised the rarity of *C. maximus* in Turkish waters.

Family Alopiidae Bonaparte, 1835

The Alopiidae family is represented in Turkish seas with 2 species: *Alopias uperciliosus* Lowe, 1841, and *A. vulpinus* (Bonnaterre, 1788). The first record of bigeye thresher shark, *A. superciliosus*, in Turkish waters dates back to the early 2000s (Mater, 2005; Bay of Gökova, southeastern Aegean Sea); a few years later there was another record from the Sea of Marmara (Kabasakal & Karhan, 2008), followed by several other Aegean records (Kabasakal *et al*., 2011). The female specimen of bigeye thresher shark, 472 cm in TL, caught on 9 April 2019 off Çevlik coast (NE Levantine Sea) was one of the largest specimens of *A. superciliosus* ever recorded in the Mediterranean Sea and worldwide (Ergüden *et al*., 2020b). Despite its open water occurring habits, Kabasakal (2007) reported on the coastal occurrences of 19 common thresher sharks, *A. vulpinus*, which were incidentally captured by coastal stationary netters. Recently, Ergüden *et al*. (2015) reported on an incidental capture of a single male thresher shark, of 392 cm TL and weighing ca. 180 kg, in purse-seine fishery in İskenderun Bay, which was the first record of *A. vulpinus* from the northeastern Mediterranean coast of Turkey. Ayas *et al*. (2020) reported on the occurrence of pregnant and young specimens of *A. vulpinus* in the northeastern Mediterranean Sea, as well. Of the total number (n=392) of large sharks caught in Turkish waters by commercial fishermen between 1990 and August 2015, *A. superciliosus* and *A. vulpinus* accounted for a 2.5% and a 9.9% share, respectively (Kabasakal *et al*., 2017).

Order Carcharhiniformes

Family Pentanchidae Smith, 1912

Galeus melastomus Rafinesque, 1810, is a common deep-sea cat shark species in Marmara, and the Turkish Aegean and Mediterranean seas (Meriç, 1995; Kabasakal, 2002; Kabasakal & Kabasakal, 2004; Özütemiz *et al*., 2009; Oral, 2010). According to Bengil & Başusta (2018), *G. melastomus* is one of the species with major shares of shark bycatches in Turkish waters.

Family Scyliorhinidae Gill, 1862

The family Scyliorhinidae is represented in Turkish seas with 2 species: *Scyliorhinus canicula* (Linnaeus, 1758) and *S. stellaris* (Linnaeus, 1758). Contemporary occurrences of cat sharks *S. canicula* and *S. stellaris* in Turkish waters were confirmed by Kabasakal (2002), Kabasakal & Kabasakal (2004), İşmen *et al*. (2013), Kabasakal & Karhan (2015), Yağlıoğlu *et al*. (2015), and Başusta *et al*. (2016). In a recent review of chondrichthyan species as bycatch in Turkish waters, Bengil & Başusta (2018) stated that almost half of the bycatch recorded in Turkish waters consists of small spotted catshark.

Family Triakidae Gray, 1851

The family Triakidae is represented in Turkish seas with 2 genera and 4 species: *Galeorhinus galeus* (Linnaeus, 1758), *Mustelus asterias* Cloquet, 1819, *M. mustelus* (Linnaeus, 1758), and *M. punctulatus* Risso, 1827. Filiz & Mater (2002), Kabasakal & Kabasakal (2004), Yağlıoğlu *et al*. (2015), Başusta *et al*. (2016), and Kabasakal (2020b) confirmed contemporary occurrences of *G. galeus*, *M. asterias*, *M. mustelus,* and *M. punctulatus* in Turkish waters. Kabasakal *et al*. (2017) stated that *G. galeus* represented less than 2% of the total shark biomass recorded in the Turkish commercial fisheries between 1990 and 2015. Two specimens of starry smoothhound, *M. asterias*, were captured three miles off the coast of Şile (southwestern Black Sea) on 19 November 2000 at a depth of ca. 90 m, and this record extended the Mediterranean distribution of *M. asterias* into the Black Sea (Eryılmaz *et al*., 2011). Recently, Bengil (2020) recorded *M. asterias* in the Levantine Sea, and *M. mustelus* and *M. punctulatus* in Turkish Aegean waters.

Family Carcharhinidae Jordan and Evermann, 1896

The family Carcharhinidae is represented in Turkish seas with 2 genera and 9 species: *Carcharhinus altimus* (Springer, 1950), *C. brachyurus* (Günther, 1870), *C. brevipinna* (Valenciennes, 1839), *C. falciformis* (Bibron, 1839), *C. limbatus* (Valenciennes, 1839), *C. obscurus* (Lesueur, 1818), *C. plumbeus* (Nardo, 1827), and *Prionace glauca* (Linnaeus, 1758). Contemporary occurrences of *C. altimus*, *C. brachyurus*, *C. brevipinna*, *C. falciformis*, *C. limbatus*, *C. obscurus*, *C. plumbeus*, and *Prionace glauca* in Turkish waters were confirmed in several studies (Kabasakal & Kabasakal, 2004; Filiz & Kabasakal, 2015; Yağlıoğlu *et al.,* 2015; Kabasakal *et al.,* 2017; Bengil, 2020; Ergüden *et al*., 2020c,d; Kabasakal & Bilecenoğlu, 2020; Kabasakal, 2020b). Since the occurrence of *C. melanopterus* is based on an old record by Mater & Meriç (1996), and the questionable status of the species was emphasised by Serena *et al*., (2020), further investigation is needed to clarify its questionable status in Turkish waters. In an extensive survey on the chondrichthyan fishes of İskenderun Bay (northeastern Mediterranean Sea), Başusta *et al*. (1998) recorded the big nose shark, *C. altimus*, for the first time in Turkish waters, followed by a recent capture of a few specimens in Turkish Mediterranean waters (Ayas *et al*., 2020). Recent surveys confirm the occurrence of the dusky shark, *C. obscurus* off the Turkish coast of the Levantine Sea (Kabasakal *et al.,* 2017; Kabasakal & Bilecenoğlu, 2020). Occurrence of the spinner shark, *C. brevipinna*, was confirmed by Filiz & Kabasakal (2015) based on a specimen of the species photographed in Bay of Gökova, and several other specimens have recently been recorded in Antalya and Mersin gulfs (Ayas *et al*., 2019; Kabasakal & Bilecenoğlu, 2020). In an extensive survey of large sharks in Turkish waters, based on data mining from reliable online sources, *C. brachyurus* and *C. falciformis* were recorded for the first time in Turkish Mediterranean waters (Kabasakal & Bilecenoğlu, 2020). In terms of abundance, *C. plumbeus* and *P. glauca* are the most common carcharhinid sharks occurring in the Aegean and Mediterranean waters of Turkey (Kabasakal, 2020b).

Family Sphyrnidae Bonaparte, 1840

Our knowledge on hammerhead sharks (family Sphyrnidae) in Turkish waters is consisted of rudimentary data. Ulutürk (1987) and Kabasakal & Kabasakal (2004) reported on rare occurrences of the smooth hammerhead shark, *Sphyrna zygaena* (Linnaeus, 1758), off Gökçeada coasts (northern Aegean Sea). Recently, in August 2015, it was observed off the Kaş Peninsula (western Levantine basin) (Kabasakal *et al.,* 2017). Although its occurrence was confirmed, *S. zygaena* is considered as a rare shark in Turkish waters (Kabasakal, 2020b).

Order Squaliformes

Family Dalatiidae Gray, 1851

Kabasakal & Kabasakal (2002) reported rare occurrences of *Dalatias licha* (Bonnaterre, 1788), caught in deep-water bottom-trawl fishery in the northern Aegean Sea. Recently, an adult female of *D. licha*, 118 cm TL, became entangled in a trammel net set at a depth of 40 m in Iskenderun Bay (northeastern Mediterranean sea) (Ergüden *et al.,* 2017). In June 2018 a specimen of *D. licha* was stranded on Alanya coast (Gulf of Antalya, eastern Mediterranean Sea) (Kabasakal & Bilecenoğlu, 2020).

Family Etmopteridae Fowler, 1934

Occurrences of *Etmopterus spinax* (Linnaeus, 1758) in bottom trawl fishery have been reported from Turkish Aegean and Mediterranean waters (Kabasakal & Ünsal, 1999; Kabasakal & Kabasakal, 2004; Bilge *et al*., 2010; Başusta, 2015; Bayhan *et al*., 2018). Velvet belly is a more frequent bycatch in demersal fishery conducted in Aegean waters, where the occurrence of hundreds of neonates and juveniles suggests a bathyal nursery ground in the region (Kabasakal & Kabasakal, 2004; Bilge *et al*., 2010).

Family Somniosidae Jordan, 1888

Serena *et al*. (2020) considered *Somniosus rostratus* (Risso, 1827) as a rare shark in the eastern Mediterranean. Recently, Irmak & Özden (2021) reported the occurrence of this species in Turkish waters based on a specimen incidentally caught by a swordfish (*Xiphias gladius*) longline off Fethiye coast (southeastern Aegean Sea) in November 2008. Irmak & Özden (2021) also re-

ported that the longline was broken and dropped below at least a depth of 2500 m; thus, the sampling depth of the mentioned specimen is among the deepest observation points of the species in the Mediterranean Sea. *S. rostratus* is an extant, but rare shark in Turkish waters.

Family Oxynotidae Gill, 1863

Oxynotus centrina (Linnaeus, 1758) occurs in the Marmara, Aegean, and Mediterranean seas (Başusta *et al.*, 2015; Yığın *et al.*, 2016; Kabasakal, 2020b), and is considered as a rare and threatened species in Turkish waters. A recent review on the occurrence and status of *O. centrina* in the eastern Mediterranean (Kabasakal, 2015b) revealed that between the late 1800s and 2012, the highest number of *O. centrina* specimens (72%) was recorded in the Aegean Sea, followed by the Sea of Marmara (21.5%).

Family Centrophoridae Bleeker, 1859

In the recent field guide to the sharks of Turkish waters, two species of the Centrophoridae are listed, *Centrophorus granulosus* and *C. uyato* (Kabasakal, 2020b). However, the validity of *C. granulosus* and *C. uyato* is still debated among taxonomists (Serena *et al.*, 2020). Some researchers suggest that the Mediterranean species of *Centrophorus* should be named *C. uyato*, while others propose a new description of the species with a new neotype (Serena *et al.*, 2020). Following the current recommendations given by Serena *et al.* (2020), I consider *Centrophorus* cf. *uyato* (Rafinesque, 1810), as a valid species in Turkish waters. Although the specimens of *Centrophorus* from the Marmara Sea in the early 1990s were identified as *C. granulosus* (Benli *et al.*, 1993), they should be re-examined for correct identification and naming. A single recording of *C.* cf. *uyato* from the northern Marmara bathyal has been reported by Meriç (1995). *C.* cf. *uyato* is an extant but rare shark in Turkish waters.

Family Echinorhinidae Gill, 1862

Although *Echinorhinus brucus* (Bonnaterre, 1788) had long been considered extinct in Turkish waters, in October 2002, a bramble shark *E. brucus* was imaged at a depth of 1,214 m in the northern Marmara Sea (Kabasakal *et al.,* 2005). Recent studies provide further records confirming the contemporary existence of *E. brucus* in Turkish waters (Kabasakal & Dalyan, 2011; Kabasakal & Bilecenoğlu, 2014; Kabasakal, 2017b). Available data reveal that *E. brucus* is an extant but rare shark species in Turkish waters.

Order Squatiniformes

Family Squatinidae de Blainville, 1816

The family Squatinidae is represented in Turkish seas with 3 species: *Squatina aculeata* Cuvier, 1829, *S. oculata* Bonaparte, 1840 and *S. squatina* (Linnaeus, 1758). Contemporary occurrences of S. *aculeata*, *S. oculata,* and *S. squatina* have been confirmed by Başusta (2002), Filiz *et al*. (2005), Başusta (2015), Yağlıoğlu *et al*. (2015), Ergüden & Bayhan (2015b), Ergüden *et al*. (2019), Kabasakal (2019b), Yığın *et al*. (2019), and Bengil (2020). *S. squatina* is considered as one of the largest sharks in Turkish waters and, historically, it was one of the commercially important shark species in Turkish demersal fishery (Kabasakal *et al*., 2017; Kabasakal, 2019b). However, there has been an alarming decrease recorded in angel shark populations and the survival of this species may be threatened. As recent surveys show, *S. squatina* accounts for less than 2% of the total shark biomass incidentally caught by Turkish fishermen (Yağlığlu *et al.,* 2015; Kabasakal *et al.,* 2017), and its populations has drastically declined since the early 2000s (Kabasakal, 2019b). All three species of *Squatina* are now considered as endangered species in Turkish seas.

Questionable species

In previous studies, Akşıray (1987), and Mater and Meriç (1996) included *Carcharhinus longimanus* (Poey, 1861), *C. melanopterus* (Quoy and Gaimard, 1824), *Sphyrna lewini* (Griffith and Smith, 1834), and smalleye hammerhead shark, *Sphyrna tudes* (Valenciennes, 1822), in the list of marine ichthyofauna of Turkey. However, there are no confirmed reports of living individuals of these species in Turkish waters. Furthermore, Akşıray (1987) has not given any information on where the specimens of these species were captured or are being preserved for further examination. The most recent review of species diversity of chondrichthyes in the Mediterranean Sea by Serena *et al*. (2020) does not include *C. longimanus* among the Mediterranean fauna and considers the occurrence of *C. melanopterus* as questionable. The status of occurrence of *S. lewini* and *S. tudes* in the Mediterranean Sea is considered as rare and vagrant, respectively (Serena *et al*., 2020). Bariche (2012) included the scalloped hammerhead shark, *S. lewini,* in his recent field guide of marine resources of the eastern and southern Mediterranean, but considers *S. lewini* very rare to absent in the region. For the moment, according to reports by Serena *et al*. (2020), *C. longimanus* cannot be included in the Mediterranean fauna. The occurrence statuses of *C. melanopterus, S. lewini,* and *S. tudes* in Turkish waters have always been a subject of debate, therefore these species, considered as questionable by contemporary ichthyologists, and are not included in current ichthyological inventories of the seas of Turkey (e.g., Bilecenoğlu *et al*., 2014; Kabasakal, 2020b). Further research is required to clarify the presence of *C. melanopterus, S. lewini,* and *S. tudes* in Turkish waters.

Nursery grounds of sharks along Turkish coasts

In terms of survival and management of shark populations, nursery grounds, where the parturition and development of new generations of sharks occur, are considered as critical habitats. Therefore, the mapping of these areas is of high importance. Following the surveys performed during the last two decades, four possible nursery grounds of sharks were discovered along the Turkish coast, three in the Aegean Sea and one in the northeastern Mediterranean Sea (Kabasakal & Kabasakal, 2004; Filiz & Gülşahin, 2015; Kabasakal, 2020c; Başusta *et al*., 2021).

Based on incidental captures of neonates with healing umbilical scars on the belly, Kabasakal & Kabasakal (2004) suggested that the bathyal grounds off the northern coasts of Gökçeada (northeastern Aegean Sea) may serve as a breeding ground for *Hexanchus griseus*, *Scyliorhinus canicula*, *Etmopterus spinax*, and *Dalatias licha*. According to Filiz & Gülşahin (2015), Boncuk Bay (southeastern Aegean Sea) is a confirmed nursery ground of *Carcharhinus plumbeus*, where yearly aggregations of pregnant females occur periodically from May to July (Filiz, 2018). According to Kabasakal (2020c), Edremit Bay (northeastern Aegean Sea) may serve as a nursery ground for *Carcharodon carcharias,* whereas the surrounding insular marine area outside of the bay waters may serve as a growing and feeding ground for juveniles until maturity. Last but not least, based on the records of neonate sandbar sharks in Arsuz coast (Iskenderun Bay) and Yumurtalık Bight (NE Mediterranean Sea), Ergüden *et al*. (2020c) and Başusta *et al*. (2021) suggested that this area may represent a second breeding and nursery ground for *C. plumbeus*, after Boncuk Bay, along the Turkish coast. The combined results of these studies provide solid evidence of the occurrence of multiple shark nurseries along the Turkish coasts, therefore an effective management of these grounds is crucial to the overall survival and biodiversity of Mediterranean sharks.

Bycatch of sharks in Turkish waters

There has been a considerable increase in the number of studies on the status of sharks incidentally captured during commercial fishing in Turkish waters. Bycatch of sharks were reported both in pelagic and demersal fisheries, emphasising a multimodal threat to the survival of sharks in Turkish seas (Bök *et al*., 2011; Ceyhan & Akyol, 2014; Yağlıoğlu *et al*., 2015; Filiz *et al*., 2018; Bengil & Başusta, 2018). According to Bengil and Başusta (2018), nearly half of the cartilaginous fish species (n=76) living in Turkish waters are particularly threatened from bycatch, which is a serious threat to the overall survival and future of cartilaginous fish in the eastern Mediterranean. In a recent study, Kabasakal *et al*. (2017) examined large shark species incidentally captured by commercial fishing gear in Turkish waters and the amount of catches of these species between 1990 and August 2015. Summing up, we can say that sharks are captured as "non-target species" in commercial fisheries in Turkish waters. In the recently published national action plan for the conservation of cartilaginous fishes of Turkish waters (Öztürk, 2018), bycatch in trawl, trammel net and purse seine unreported and unregulated fishing has been listed as the main threat for the cartilaginous species, occurring in the mentioned region.

Conservation of sharks in Turkish waters

Degradation of important nursery grounds and other critical coastal habitats due to marine pollution, overfishing, coastal urbanisation, and unplanned human occupation is another serious threat to the survival of sharks. A recent research on the extinction risk and conservation of globally distributed lineage of 1,041 chondrichthyan species emphasised that the extinction risk of chondrichthyans is substantially higher than that in most other vertebrates, and only one third of chondrichthyan species are considered safe (Dulvy *et al*., 2014). Following the revisions proposed in the national action plan (Öztürk, 2018), which were positively implemented in the fisheries act of Turkey (Official Gazette 2016, 2018; Öztürk, 2018; Official Gazette 2020), the following shark species are currently considered under protection: *Carcharhinus falciformis, C. plumbeus, Prionace glauca, Galeorhinus galeus, Sphyrna zygaena, Cetorhinus maximus, Isurus oxyrinchus, Lamna nasus, Alopias superciliosus, A. vulpinus, Squalus acanthias, S. blainvillei, Oxynotus centrina, Squatina aculeata, S. oculata*, and *S. squatina*. The fisheries act prohibits any person under Turkey's jurisdiction to kill and/or land the sharks from the list of protected species, and any violation of this law is sanctioned by a fine. It is an urgent necessity for some species, including large shark species, of whose population structures we still do not know much, to be included in the protection scope immediately. One of these species is *Carcharodon carcharias*, which is critically endangered in the Mediterranean Sea and was listed in Annex II (Endangered or Threatened species) of the protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean of the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean. Being a signatory state of the Barcelona Convention, Turkey should take immediate action to protect *C. carcharias*.

CONCLUSIONS

Following the publication of *A Field Guide to the Sharks of Turkish Waters* in early summer 2020 (Kabasakal, 2020b), three remarkable events happened that have made the revision of the published species list a necessity. The first event was related to the first records of *Carcharhinus brachyurus* and *C. falciformis* in Turkish

waters (Kabasakal & Bilecenoğlu, 2020). The second was the publication of a milestone article on the species diversity, taxonomy, and distribution of Mediterranean and Black Sea chondrichthyans (Serena *et al.*, 2020), which indicates *Centrophorus* cf. *uyato* as a valid species of the genus *Centrophorus* and reveals *Carcharhinus melanopterus* as a questionable species in the region. The last event was the confirmation of the presence of *Somniosus rostratus* in Turkish waters (Irmak & Özden, 2021).

Available data have revealed that the current shark fauna of the Turkish waters includes 37 confirmed species. Questionable occurrences of *C. melanopterus, S. lewini*, and *S. tudes*, which are included in relevant ichthyological inventories of Turkish waters (Akşıray, 1987; Mater & Meriç, 1996), require confirmation. Although, Akşıray (1987) also mentioned the occurrence of *C. longimanus* in Turkish shark fauna, the species is not included in the present inventory due to its absence in the entire Mediterranean (Serena *et al.*, 2020).

When the results of the current study (n=37 species) are compared with the list, which was published in the early 2000s and includes 31 species (Kabasakal, 2002), it can be seen that remarkable changes have taken place over the past 20 years. It has been confirmed that *Carcharias taurus*, *Carcharhinus limbatus*, *C. obscurus*, and *Echinorhinus brucus*, which are listed as questionable in the list provided by Kabasakal (2002), occur in Turkish waters (Cengiz *et al.*, 2011; Kabasakal *et al.*, 2017; Kabasakal & Bilecenoğlu, 2020). Although Kabasakal (2002, 2020b) reported that *Centrophorus granulosus* and *C. uyato* occur in Turkish waters, in the light of current information (Serena *et al.*, 2020), the status of the species of the genus *Centrophorus* in the region should be updated to that of *C.* cf. *uyato*. During this period, three new record species (*Alopias superciliosus*, *Carcharhinus brachyurus*, and *C. falciformis*) were included in the shark fauna of Turkey (Mater, 2005; Kabasakal & Bilecenoğlu, 2020).

Based on current information, it can be observed that the most important threat to sharks in Turkish waters comes from bycatch (Bök *et al.*, 2011; Ceyhan & Akyol, 2014; Yağlıoğlu *et al.*, 2015; Filiz *et al.*, 2018; Bengil & Başusta, 2018). Although considerable efforts have been made in recent years to protect the generations of sharks and prevent them from being harmed by incidental captures, sharks cannot be safe from bycatch fishery. The necessity and value of legal regulations for the purpose of protection of shark species is unquestionable and obvious. However, fisheries news in published or internet media, as well as in social media, give the impression that these legal measures are not yet deterrent. Although fines have started to be imposed, it is a concrete fact that we are still far from an awareness of conservation based on ecological facts and where fishermen respect sharks as “the species that have a fundamental place in the balance of the ecosystem.” Releasing sharks back into the sea is an important but not the only measure to implement, as their survival is also profoundly affected by the conditions during the handling. Fishermen must understand the need for sharks in the ecosystem. Only protective efforts will come to a conclusion if this awareness is achieved.

The last but not least important issue is the potential of the increasingly numerous aquaculture facilities to attract especially large sharks to the coasts. Although sharks are active predators, they can also be opportunistic feeders, which do not refuse the easy feeding environment that aquaculture facilities offer. Concentrations of predatory sharks are increasingly being recorded around aquaculture facilities off the Turkish coast, as in different parts of the world (Kabasakal & Gedikoğlu, 2015). A recent provoked sandbar shark (*Carcharhinus plumbeus*) attack on commercial divers near an aquaculture cage (Ergüden *et al.*, 2020d) is representative of the potential threat to the public that can result from the stimulating effect of aquaculture facilities.

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PREGLED PESTROSTI MORSKIH PSOV V TURŠKIH MORJIH: DOPOLNJEN SEZNAM, NOVI PRIŠLEKI, VPRAŠLJIVE VRSTE IN NARAVOVARSTVENI PROBLEMI

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POVZETEK

Favna morskih psov v turških morjih šteje po do sedaj zbranih podatkih 37 potrjenih vrst: Hexanchus griseus, Heptranchias perlo, Echinorhinus brucus, Squalus acanthias, S. blainvillei, Centrophorus *cf.* uyato, Etmopterus spinax, Somniosus rostratus, Oxynotus centrina, Dalatias licha, Squatina aculeata, S. oculata, S. squatina, Carcharias taurus, Odontaspis ferox, Alopias superciliosus, A. vulpinus, Cetorhinus maximus, Carcharodon carcharias, Isurus oxyrinchus, Lamna nasus, Galeus melastomus, Scyliorhinus canicula, S. stellaris, Galeorhinus galeus, Mustelus asterias, M. mustelus, M. punctulatus, Carcharhinus altimus, C. brachyurus, C. brevipinna, C. falciformis, C. limbatus, C. obscurus, C. plumbeus, Prionace glauca, *in* Sphyrna zygaena. *Na podlagi zdajšnjih podatkov morske pse v turških morjih v največji meri ogroža prilov.*

Ključne besede: Elasmobranchii, seznam vrst, pregled stanja, Turčija

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GREAT WHITE SHARKS, *CARCHARODON CARCHARIAS*, HIDDEN IN THE PAST: THREE UNPUBLISHED RECORDS OF THE SPECIES FROM TURKISH WATERS

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ABSTRACT

Three previously unpublished records of the great white shark, Carcharodon carcharias *(Linnaeus, 1758), in Turkish waters were discovered through social media and internet data mining. Two of the individuals were recorded in the Sea of Marmara and the third in Edremit Bay (northeastern Aegean Sea). Understanding the historical occurrence and abundance of sharks in a given geographic area is critical. Thus, citizen science, social media supported studies, and analyses of historical data, which have produced relevant results in recent years, will undoubtedly help toward a more effective protection and management of this top predator.*

Key words: historical data, citizen science, social media, sharks, megafauna

GRANDI SQUALI BIANCHI, *CARCHARODON CARCHARIAS*, NASCOSTI NEL PASSATO: TRE RITROVAMENTI INEDITI DELLA SPECIE IN ACQUE TURCHE

SINTESI

Tre registrazioni inedite del grande squalo bianco, Carcharodon carcharias *(Linnaeus, 1758), in acque turche sono state scoperte attraverso i social media e il data mining di internet. Due degli individui sono stati registrati nel Mar di Marmara e il terzo nella baia di Edremit (Egeo nord-orientale). Comprendere la presenza storica e l'abbondanza di squali in una data area geografica è fondamentale. Quindi, la citizen science, gli studi supportati dai social media e le analisi dei dati storici, che hanno prodotto risultati rilevanti negli ultimi anni, aiuteranno senza dubbio a rendere più efficace la protezione e la gestione di questo grande predatore.*

Parole chiave: dati storici, scienza dei cittadini, social media, squali, megafauna

INTRODUCTION

The great white shark, *Carcharodon carcharias* (Linnaeus, 1758) (Lamniformes: Lamnidae), is a globally widespread apex predator (Moro *et al*., 2020). It is a large shark with an estimated total length of up to 640 cm (Randall, 1973), occurring circumglobally, but mostly in warm-temperate waters and less frequently in tropical regions, from the surface waters to depths of over 1280 m (Ebert & Stehmann, 2013). Once stigmatised as a man-eating monster, it has now resurrected as a charismatic flagship member of the marine megafauna and one of the stars of conservation action (Mazzoldi *et al*., 2019).

In truth, historical and contemporary occurrences of *C. carcharias* have always been an attractive topic in the field of shark research (e.g., De Maddalena & Heim, 2012; Kabasakal, 2020a). In a recent study, Moro *et al*. (2020) reported 773 verified historical and contemporary records of *C. carcharias* from several regions of the Mediterranean Sea. Data on the occurrence of the great white shark in Turkish waters include a total of 62 historical and contemporary records (Kabasakal, 2020a).

In the present article, authors report the occurrence of 3 previously unpublished records of *C. carcharias* from Turkish waters, based on historical photographs.

MATERIAL AND METHODS

This article is part of an ongoing research begun in the early 2000s for the purpose of collecting and archiving historical and contemporary occurrence data of *Carcharodon carcharias* in Turkish waters, at the initiative of the Ichthyological Research Society. The results of the project called Turkish Great White Shark Data Archive (TGWSDA), comprised of data on 62 specimens and their images, gathered over the past 20 years, were recently published (Kabasakal, 2020a). The data concerning the 3 unpublished records of *C. carcharias* specimens caught in Turkish waters were obtained through data mining in the digitalized media of old newspapers published between the 1900s and the 1930s (2 specimens), as well as in contemporary internet news portals (1 specimen). Historical and contemporary photographs of the great white shark accompanied by informative content were published on social media platforms such as Facebook and Instagram, which are now accepted as important sources of information attracting a remarkably increasing interest of researchers (e.g., Boldrocchi & Storai, 2021; Kabasakal & Bilecenoğlu, 2020; Giovos *et al*., 2021). Since online communities and website administrators may react negatively to the use of their online content by researchers, following the ethical code proposed by Monkman *et al*. (2017), all internet content scraping activity was performed responsibly to avoid compromising any personal data or image. An individual shark record was considered valid if the respective digital photograph provided a clear side view of the specimen, or in the case of video footage, if the shark was visible for a reasonable enough time, ca. 5 seconds, allowing the capture of a still image for the identification of the shark species. The species identification of the specimens in the extracted photographs followed the descriptive characters presented by De Maddalena & Heim (2012) and Ebert & Stehmann (2013). Moreover, to crosscheck the validity of the identification, the extracted images of the historical specimens were compared to photographs of contemporary specimens of *C. carcharias* captured in an identical or similar perspective. To provide a visual guideline for a quick crosscheck, the historical and the contemporary photographs of the respective great white shark were shown side by side. The examined photographs are preserved in the personal archive of the first author and available for inspection on request. The length and weight data of the examined specimens of *C. carcharias* are based on the information provided in the accompanying news content related to the respective great white shark.

RESULTS AND DISCUSSION

The examined three specimens (Figs. 1 above, 2 left, centre, 3 centre) were identified as *Carcharodon carcharias* (Linnaeus, 1758) on the basis of the following characteristics: all three specimens had prominent triangular teeth. Likewise, the snouts exhibited a strong and conical structure. In addition, the black spots on the tip of the nose of specimen 3, captured on 14 July 2010, and the black spots on the ventral surfaces of the pectoral fin tips (Fig. 3 centre) were consistent with the black spots seen on the same body parts in the contemporary comparison photographs of great white shark (Figs. 3 left, right). The dental structure and the black mottling of the examined specimens both coincided with the descriptive characters stated by De Maddalena & Heim (2012) and Ebert & Stehmann (2013).

Specimen 1 (Fig. 1) was caught off the Prince Islands in the northeastern Marmara Sea on 2 February 1926 (Fig. 4; spec. 1). Information about the capture of specimen 1 was obtained from the news compiled by Malkoç (2018) from the newspapers of the period. According to the news published in İkdam, one of the newspapers of the period, on 2 February 1926, the great white shark caught by Yakup Kaptan and Kalkavanzade İbrahim Kaptan was misidentified as *dogfish* (*camgöz* in Turkish), and unfounded rumours of a human skeleton, three

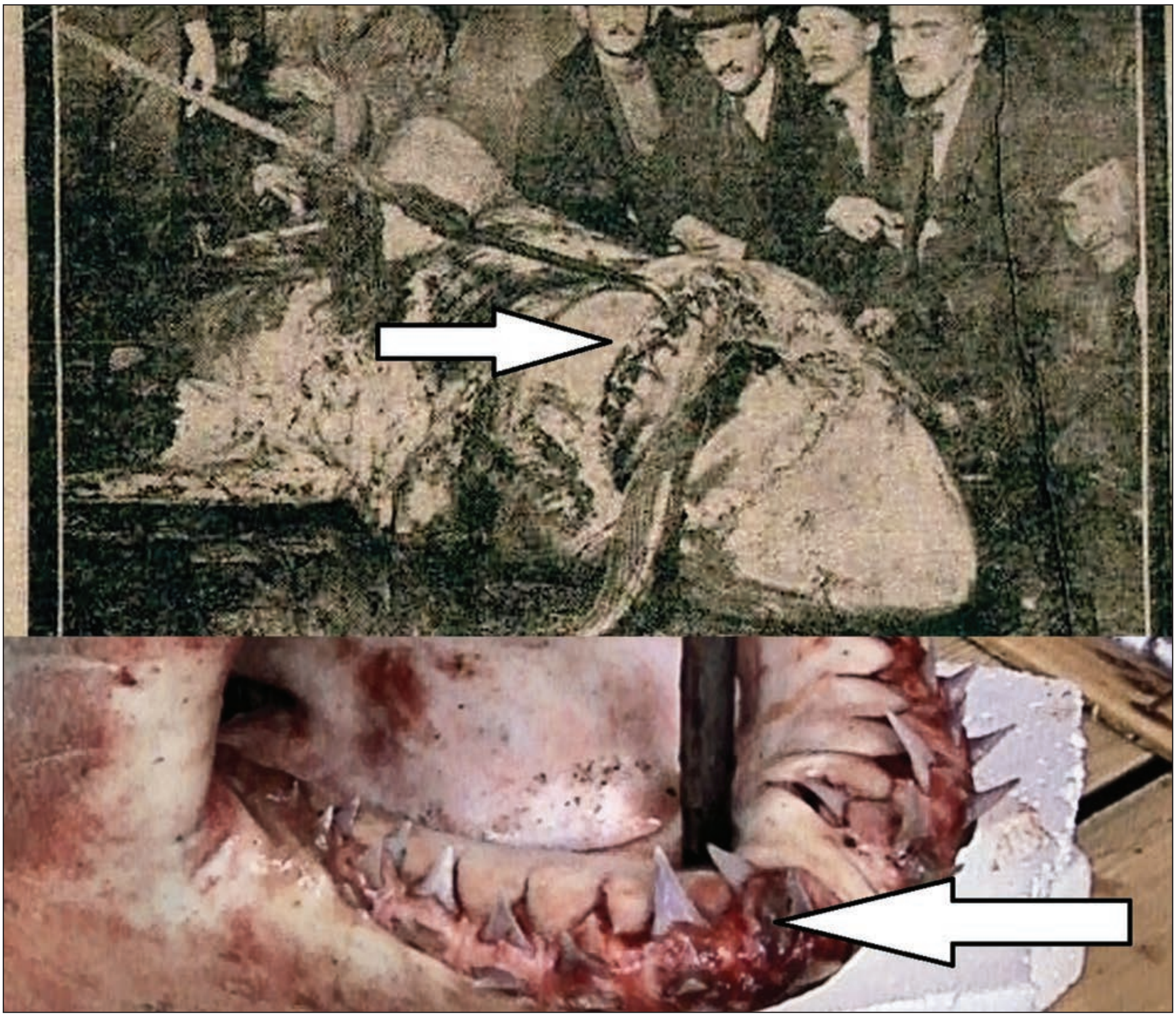


Fig. 1: (Above) Great white shark (spec. 1) caught on 2 February 1926; (below) comparison specimen published in Kabasakal** et al.* ***(2009). Arrows indicate teeth on the lower jaw.
Sl. 1: (Zgoraj) Beli morski volk (osebek 1), ujet 2. februarja 1926; (spodaj) primerjalni osebek, objavljen v Kabasakal** et al.* ***(2009). Puščice kažejo na zobovje spodnje čeljusti.

pairs of boots, and a fez – traditional Ottoman men's headwear – having been found in the stomach of the shark were also mentioned. According to the newspaper report, the great white shark was estimated to be 500 cm long, 150 cm wide, and weighing 2000 kg (Malkoç, 2018). The newspaper article further reported that the shark had teeth the size of a big human finger and its mouth opening was 68 cm wide. The shark, which was displayed to the public in Istanbul, was the subject of news in several other newspapers over the following days, accompanied by exaggerated claims that its weight, initially stated at 2000 kg, was 3000 or even 5000 kg (Malkoç, 2018).

Specimen 2 (Fig. 2, left, centre) was caught off Büyükada in 1936 (Fig. 4; spec. 2). The news accompanying the photograph of this great white shark stated it was 500 cm long and weighing 3000 kg. Since the information about this specimen appears to be limited to one newspaper clipping, this is all the data available on it. Finally, specimen 3 (Fig. 3, centre) was caught more recently, on 14 July 2010, off the coast of Küçükkuyu (Edremit Bay; Fig. 4, spec. 3). According to the local news portal Çanakkale İçinde (2010), the great white shark, which was entangled in unspecified nets deployed by fisherman Ahmet Karabıyık, was 150 cm long and weighed 30 kg. Specimen 3 was incidentally caught in the

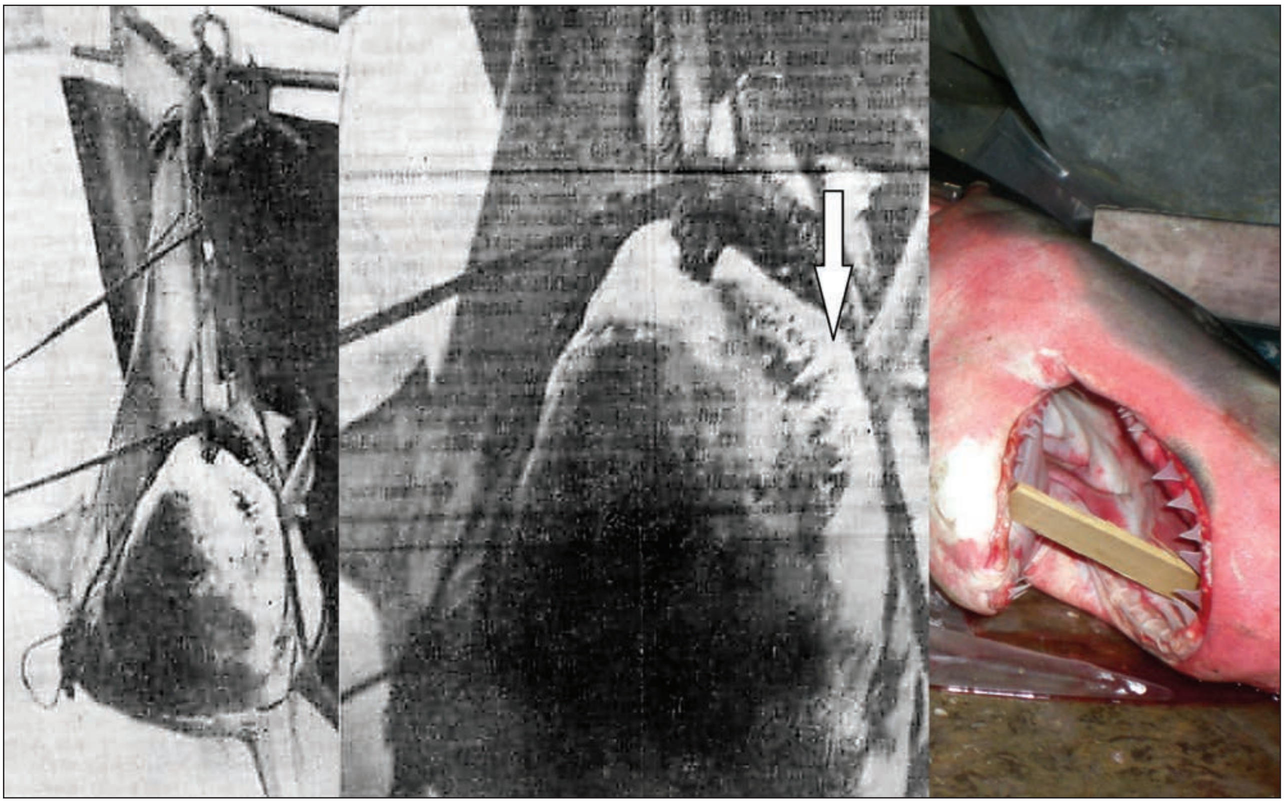


***Fig. 2: (Left, centre) Great white shark (spec. 2) caught off Büyükada in 1936; (right) comparison specimen published in Kabasakal and Gedikoğlu (2008). Arrows indicate the characteristic triangular dentition of** Carcharodon carcharias.*
Sl. 2: (levo, sredina) Beli morski volk (osebek 2), ujet blizu Büyükada v letu 1936; (desno) primerjalni osebek, objavljen v Kabasakal & Gedikoğlu (2009). Puščice označujejo značilno trikotno zobovje belega morskega volka.

recently documented nursery ground of *C. carcharias* in the northeastern Aegean Sea (Kabasakal, 2020b). Specimens 1 and 2 were incidentally caught in bluefin tuna, *Thunnus thynnus*, handline fishing, which was common in Marmara between the 1900s and the 1930s, while specimen 3 was incidentally caught in coastal artisanal net fishery.

With the addition of these individuals to those registered with the TGWSDA, the number of great white sharks recorded to date in Turkish waters has increased to 65. This figure corresponds to 8.4 percent of the total number of individuals (n=773) reported from the Mediterranean by Moro *et al*. (2020). This study is a recent example that researchers are hesitant to accept the status quo, demonstrating that the use of historical photography/data, data mining in social media or the internet, and citizen science, can yield remarkable and highly accurate results in shark research. The number of studies on Mediterranean great whites and other sharks using similar methodologies is increasing (e.g., Kabasakal, 2003,2020a; Zogaris & De Maddalena, 2014; Boldrocchi & Storai, 2021; Giovos *et al*., 2021; Jambura *et al*., 2021).

Scientists tend to value anecdotal historical reports less than more recent data collected in the field; however, Kwok (2017) describes historical photographs or old newspapers as “gold mines” of researchers working in fields such as ecology, and data mining such sources as “travelling in time.” Therefore, comparison with current photographs can be seen as a valid way of verifying the historical material in question.

Understanding the historical occurrence and abundance of sharks in a given geographic area is critical. When the current absence of sharks begins to overshadow their historical occurrence and abundance, it may lead to the shifting baseline syndrome, particularly in the younger generation of researchers, which prevents a full appreciation of the population collapse of cartilaginous fish in the Mediterranean. Zogaris and De Maddalena (2014) also drew attention to this, emphasising the importance of historical and anecdotal studies in combating this syndrome. To give an example, when the historical finds of great white sharks in the Sea of Marmara that were frequently mentioned in old fishing books and old newspapers, were uncovered years later through this type of re-



Fig. 3. (Left, right) Comparison specimen published in Kabasakal and Gedikoğlu (2008); (centre) great white shark (spec. 3) caught on 14 July 2010. Arrows indicate the conical snout, triangular teeth, and black blotches on ventral surfaces of pectoral tips.
Sl. 3: (Levo, desno) Primerjalni osebek, objavljen v Kabasakal & Gedikoğlu (2008); (sredina) beli morski volk (osebek 3), ujet 14. julija 2010. Puščice kažejo koničast gobec, trikotne zobe in črne lise na trebušni strani prsnih plavuti.

search (e.g., Kabasakal 2003, 2020a), the majority of the society and some contemporary researchers were openly suspicious of them. However, the estimation of occurrence of *C. carcharias* in the Marmara Sea and the Strait of Istanbul is based on historical records of 40 specimens captured in bluefin tuna fisheries between 1881 and 1985 (Kabasakal, 2020a). Historical sites of capture of great white sharks in this region were concentrated in the Strait of Istanbul and the pre-Bosphoric waters of the Marmara Sea, in which bluefin tuna fishery has been known since the Byzantine era (4th century CE) (Kabasakal, 2020a). Further studies by De Maddalena and Heim (2012), Boldrocchi *et al*. (2017) and Moro *et al*. (2020) listed, 596, 628, and 773 records of Mediterranean great white shark, respectively, and included historical material as a remarkable part of the data sources analysed. Meticulous analyses of similar historical photographs can even change our perspective on the maximum length that *Carcharodon carcharias* could reach (Castro, 2012; De Maddalena *et al*., 2001).

To sum up the above, when researching great white sharks and other sharks in the Mediterranean, we should not overlook the related historical material. However, we should also acknowledge the importance of following a certain methodology and verifying the reliability of the historical material in question when conducting such studies. Of course, this type of research requires travelling very far back in time and digging deep. (Kwok, 2017). But it appears that social media and citizen scientists could be relied upon for help in performing such work, as both sources have repeatedly proven their potential and importance in shark research in the Mediterranean. (Kabasakal & Bilecenoğlu, 2020; Boldrocchi & Storai, 2021; Giovos *et al*., 2021; Jambura *et al*., 2021). In a similar study, Boldrocchi and Storai (2021) stated that sightings of blue sharks shared via Facebook and Instagram have increased steadily since 2010, and that social media platforms can now be considered as a primary source of opportunistic shark encounter data. The significant increase in the notifications of great white sharks,

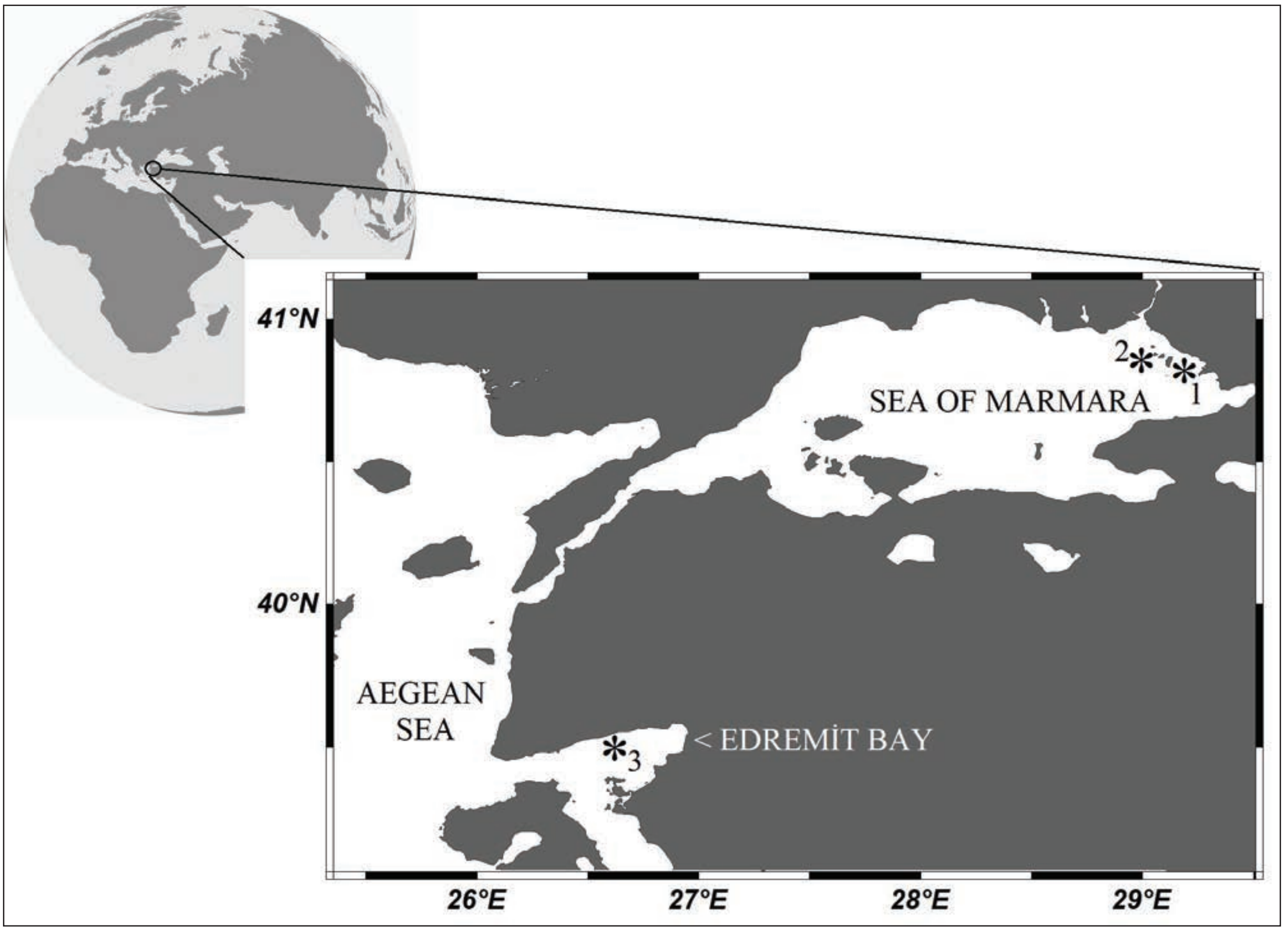


Fig. 4. Sites of captures of great white shark, specs. 1, 2 and 3, in the Sea of Marmara and in the northeastern Aegean Sea.
Sl. 4: Lokalitete ulova primerkov (1,2 in 3) belega morskega volka v Marmarskem morju in v severovzhodnem Egejskem morju.

especially on Turkish coasts since 2008, is also a result of social media and citizen scientist activity (Kabasakal 2020a; Kabasakal & Bilecenoğlu, 2020), and a similar increase has been seen off the Libyan coast, for example (Jambura *et al*., 2021).

In conclusion, the number of records of great white shark observed in Turkish waters in the past can be expected to increase, as access to historical data, which can help stimulate public engagement and conservation action (McClenachan *et al*., 2012), becomes easier with the aid of digitisation. *Carcharodon carcharias*, the flagship species of marine megafauna, was classified as vulnerable worldwide in the most recent IUCN Red List (Rigby *et al*., 2019). Although not yet part of the scientific canon, citizen science and social media supported studies and analyses of historical data, which have yielded relevant results in recent years, will undoubtedly help toward a more effective protection and management of this top predator.

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TRIJE NEOBJAVLJENI PRIMERI POJAVLJANJA BELEGA MORSKEGA VOLKA, *CARCHARODON CARCHARIAS*, IZ TURŠKIH VODA IZBRSKANI IZ PRETEKLOSTI

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POVZETEK

Trije dosedaj neobjavljeni primeri o pojavljanju belega volka, Carcharodon carcharias *(Linnaeus, 1758), v turških vodah, so bili izbrskani s podatkovnim rudarjenjem v socialnih medijih in na spletu. Dva primerka sta bila ugotovljena v Marmarskem morju, tretji pa v zalivu Edremit (severovzhodno Egejsko morje). Poznavanje historičnega pojavljanja in abundance morskih psov na določenem geografskem območju je izjemno pomembno. S tega vidika ljubiteljska znanost, raziskave socialnih medijev in analize historičnih podatkov, ki so v zadnjih letih ponudile pomembne podatke, nedvomno veliko pripomorejo k učinkoviti zaščiti in ravnanjem s tem ključnim plenilcem.*

Ključne besede: historični podatki, ljubiteljska znanost, socialni mediji, morski psi, megafavna

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FIRST SUBSTANTIATED RECORD OF CRESTED OARFISH *LOPHOTUS LACEPEDE* (OSTEICHTHYES: LOPHOTIDAE) FROM THE SYRIAN COAST (EASTERN MEDITERRANEAN SEA)

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ABSTRACT

The authors report the capture of a specimen of crested oarfish, Lophotus lacepede *Giorna, 1809, from the coast of Syria. The specimen was medium size, measuring 724 mm in total length (TL) and 701 mm in standard length (SL), and weighing 959.6 g. It displayed gonadal activity and its stomach was empty. The specimen was described, including morphometric measurements and meristic counts. This finding represents the first record of the species for Syrian waters and a new record for the Levant Basin. It also constitutes the easternmost limit of the species' extension range in the Mediterranean Sea.*

Key words: total length, total body weight, distribution, extension range, Levant Basin, eastern Mediterranean Sea

PRIMO RITROVAMENTO DEL PESCE LIOCORNO *LOPHOTUS LACEPEDE* (OSTEICHTHYES: LOPHOTIDAE) LUNGO LA COSTA SIRIANA (MEDITERRANEO ORIENTALE)

SINTESI

Gli autori riportano la cattura di un esemplare di pesce liocorno, Lophotus lacepede *Giorna, 1809, lungo la costa della Siria. L'esemplare era di medie dimensioni, misurava 724 mm di lunghezza totale (TL) e 701 mm di lunghezza standard (SL), per un peso di 959,6 g. Mostrava attività gonadica e il suo stomaco era vuoto. Nell'articolo viene descritto l'esemplare, includendo misure morfometriche e conteggi meristici. Questo ritrovamento rappresenta il primo dato della specie per le acque siriane e una nuova segnalazione per il bacino del Levante. Costituisce anche il limite più orientale dell'area di estensione della specie nel mare Mediterraneo.*

Parole chiave: lunghezza totale, peso corporeo totale, distribuzione, range di estensione, Bacino del Levante, Mediterraneo orientale

INTRODUCTION

The crested oarfish, *Lophotus lacepede* Giorna, 1809 is widely distributed in most oceans from the surface to a depth of 300 m (Knudsen, 2015). The species is known along the western coasts of the Atlantic, from the Gulf of Mexico to southern Brazil (Robins & Ray, 1986), and in southern Australia (May & Maxwell, 1986). *L. lacepede* is found in the eastern coasts of Africa (Smith & Hemstra, 1986; Knudsen, 2015) and in the waters surrounding Réunion Island (Letourneur *et al.*, 2004).

L. lacepede is known in the eastern Atlantic, off Portugal, and southward from Madeira and the Canary Islands (Palmer, 1986; Knudsen, 2015). Palmer (1986) noted that in the Mediterranean, the species occurred throughout the western Basin, but not in the eastern Basin. However, more recent observations and captures of *L. lacepede* indicate that its distribution in this sea should be reassessed. According to Minos *et al.* (2015), the species was recorded off some northern regions of the western Basin, from Gibraltar (Rey, 1983) to the Italian seas (Tortonese, 1970; Minos *et al.*, 2015) and the coast of Sicily, which also constitutes the southern extension range of the species in this basin (Ragonese *et al.*, 1997).

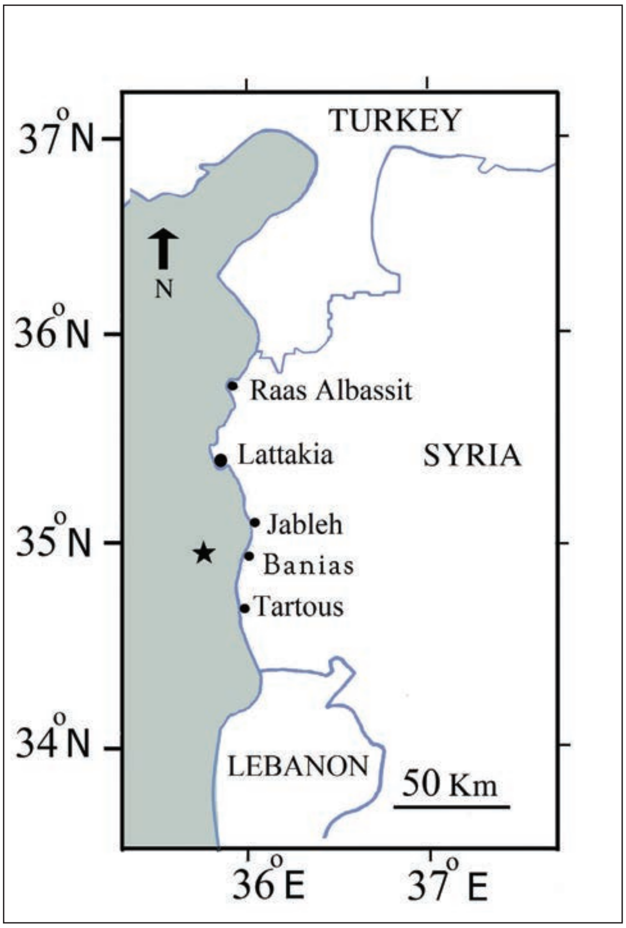


***Fig. 1: Map of the Syrian coast with the black star indicating the capture site of* Lophotus lacepede.**
Sl. 1: Zemljevid sirske obale z označeno lokaliteto ulova (črna zvezdica), kjer je bil ujet primerek čopovke.

Tab. 1: Morphometric measurements in mm and as percentages of total length (%TL), meristic counts and weight in grams recorded in the specimen of* Lophotus lacepede *collected off the Syrian coast.
Tab. 1: Morfometrične meritve, izražene v mm in kot delež celotne dolžine (%TL), meristična štetja ter teža v gramih na primerku čopovke, ujetem ob sirski obali.

Reference	**MSL 2320**	
Morphometric measurements	**mm**	**% TL**
Total length	724	100.0
Standard length	701	96.8
Body depth	118	16.3
Head length	109	15.1
Space before mouth	17	2.3
Eye diameter	31	4.3
Iris diameter	17	2.3
Pre-orbital length	43	5.9
Pre-pectoral fin length	102	14.1
Pectoral fin length	46	6.4
Pectoral fin base	16	2.2
Dorsal fin length	704	97.2
Crest length on the head (first ray of dorsal fin)	219	30.2
Pre-anal fin	661	91.3
Anal fin length	22	3.0
Anal fin base	15	2.1
Meristic counts		
Dorsal fin rays	228	
Anal fin rays	18	
Pectoral fin rays	13	
Caudal fin soft rays	19	
Lateral line scales	101	
Total wight (g)	959.6	

Further southward, *L. lacepede* is only known from the Algerian coast (Bachouche *et al.*, 2016) but is unknown to date in Morocco (Lloris & Rucabado, 1998) and Tunisia Ounifi-Ben Amor *et al.*, 2016; Rafrafi-Nouira, 2016).

L. lacepede is also known in the Adriatic Sea; historical and more recent captures were listed by Dulcic & Ahnelt (2007), and additional records of large specimens observed in the same sea were also compiled (Dulčić & Soldo, 2008; Sprem *et al.*, 2014).

Furthermore, the species has extended its distribution into the eastern Mediterranean Basin, as can be derived from captures in the Aegean Sea, in Greek waters (Minos *et al.*, 2015; Aga-Spyridopoulou *et al.*, 2019) and in Turkish waters as well (Bilecenoglu *et al.*, 2001; Tunçer & Kanat, 2019; Yapici, 2019).

Based on routine monitoring of Syrian waters in the last two decades (Saad, 2005; Ali, 2018) and through assistance of experienced fishermen, we learned that a specimen of *L. lacepede* was captured in this area. The present paper provides a short description of the specimen, including morphometric measurements and meristic counts, together with some comments about the real status of the species in the Syrian coast and the wider eastern Mediterranean Sea.

MATERIAL AND METHODS

The specimen of *L. lacepede* was caught on 14 June 2021, by commercial longline, the hook baited by small round sardinella *Sardinella aurita* Valenciennes, 1847 and sprat *Sprattus sprattus* (Linnaeus, 1758). The longline was spread out at a depth of 10–15 m and reached 500 –600 m in depth. The capture occurred about 19 km away from the Syrian shore, off Banias, 35°43¢ E and 35°11¢ N (Fig. 1). All measurements were recorded to the nearest millimetre and included in Table 1 together with meristic counts. The specimen was preserved in 10% buffered formalin and deposited in the Ichthyological Collection of the Environmental Laboratory at the Higher Institute for Environmental Research, Tishreen University.

RESULTS AND DISCUSSION

The studied specimen measured 724 mm in total length (TL) and 701 mm in standard length (SL), its total body weight was 959.6 g (Tab. 1). Palmer (1986) noted that the species size is 1.80 SL, but usually smaller. Based on the Mediterranean reports of the species, Minos *et al.* (2015) noted that its TL globally ranged between 21 and 1900 mm TL. The present *L. lacepede* specimen was a medium-sized adult female displaying conspicuous gonadal activity; its stomach was empty.

The specimen was identified as *L. lacepede* via the combination of the following morphological characters: body elongate, compressed and tapering to caudal fin; head with an occipital crest extending forward to level of mouth; teeth conical, in 3 irregular rows in both jaws; a small patch of



Fig. 2: The *Lophotus lacepede* ***collected from the Syrian coast, scale bar = 100 mm.***
Sl. 2: Primerek čopovke, ujet ob sirski obali (merilo = 100 mm).

teeth on vomer; dorsal fin long-based and low, with anterior ray elongated; anal fin short, very close to the caudal fin; pectoral fin with rays inserted horizontally; pelvic fin absent; scales thin, oblong, cycloid; lateral line present with smooth plates; colour silvery blue dorsally without brilliant spots; fins pinkish (Fig. 2).

The morphology, morphometric measurements, meristic counts, and colour are in total agreement with previous descriptions of the species (Tortonese, 1970; Palmer, 1986; Dulčić & Ahnelt, 2007; Dulčić & Soldo, 2008; Sprem *et al.*, 2014; Minos *et al.*, 2015). Therefore, *L. lacepede* could be included among the species belonging to the Syrian ichthyofauna (Ali, 2018). Although the specimen displayed gonadal activity, a single capture cannot yet confirm the presence of a viable population of *L. lacepede* in the area, however, such a hypothesis cannot be totally ruled out. Minos *et al.* (2015) listed captures of mature specimens at different stages of reproduction suggesting that *L. lacepede* is successfully established in the Mediterranean and could be considered as a solid element of the fish fauna from this sea, although it is caught only sporadically while trying to explore new areas to live and reproduce.

Minos *et al.* (2015) added that the global warming of the Mediterranean Sea (see Francour *et al.*, 1994) contributes to the homogenisation of fish fauna, and the present report of *L. lacepede* corroborates this opinion. This capture constitutes not only the first record for the Syrian coast but also a new record for the Levant Basin (Yapici, 2019), where the species has not been observed to date in some areas (Golani, 2005; Bariche & Fricke, 2020). This makes it also an indicator of the easternmost limit of the species' extension range in the Mediterranean Sea, corroborating the opinion of Minos *et al.* (2015).

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PRVI UTEMELJENI ZAPIS O POJAVLJANJU ČOPOVKE *LOPHOTUS LACEPEDE* (OSTEICHTHYES: LOPHOTIDAE) OB SIRSKI OBALI (VZHODNO SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o ulovu primerka čopovke, Lophotus lacepede *Giorna, 1809, ob sirski obali. Srednje velik primerek je meril 724 mm celotne dolžine (TL) in 701 mm standardne dolžine (SL) ter tehtal 959,6 g. Primerek je bil v fazi razmnoževalne aktivnosti, želodec je bil prazen. Avtorji so primerek natančno opisali in opravili morfometrične meritve ter meristična štetja. Najdba čopovke predstavlja prvi zapis o pojavljanju te vrste v sirskih vodah in novi primer v levantskem bazenu. Sočasno predstavlja skrajno vzhodno mejo razširjenosti te vrste v Sredozemskem morju.*

Ključne besede: celotna dolžina, celokupna teža, razširjenost, širjenje areala, levantski bazen, vzhodno Sredozemsko morje

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THE SECOND RECORD OF OILFISH, *RUVETTUS PRETIOSUS* (GEMPYLIDAE), IN TUNISIAN WATERS (CENTRAL MEDITERRANEAN SEA)

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ABSTRACT

The paper reports the second capture of a rare teleostean species, the oilfish, Ruvettus pretiosus *Cocco, 1833, in Tunisian waters. The specimen measured 133 cm in total length and weighed 25.1 kg. It was captured in northern areas of Tunisia. The scarcity of* R. pretiosus *in the study area is probably due to the fact that this species inhabits deep, poorly exploited bottoms and has a low commercial value.*

Key words: *Ruvettus pretiosus*, Tunisian waters, distribution, central Mediterranean, extension range

SECONDO RITROVAMENTO DEL RUVETTO, *RUVETTUS PRETIOSUS* (GEMPYLIDAE), IN ACQUE TUNISINE (MEDITERRANEO CENTRALE)

SINTESI

L'articolo riporta la seconda cattura di una rara specie di teleosteo, il ruvetto, Ruvettus pretiosus *Cocco, 1833, in acque tunisine. L'esemplare misurava 133 cm di lunghezza totale e pesava 25,1 kg. È stato catturato nelle zone settentrionali della Tunisia. La scarsità di* R. pretiosus *nell'area di studio è probabilmente dovuta al fatto che questa specie vive su fondali profondi e poco sfruttati e ha un basso valore commerciale.*

Parole chiave: *Ruvettus pretiosus*, acque tunisine, distribuzione, Mediterraneo centrale, range di estensione

INTRODUCTION

The oilfish, *Ruvettus pretiosus* Cocco, 1833 is widely distributed in tropical and temperate waters throughout the world (Nakamura & Parin, 1993). The species is known along the north-eastern Atlantic shore, from the British Isles to Portugal (Quéro *et al.*, 2003) and south of the Strait of Gibraltar, from Morocco (Lloris & Rucabado, 1998) to South African waters (Smith & Heemstra, 1986). *R. pretiosus* is also commonly caught off the Canaries, the Madeira Archipelago and the Cape Verde Archipelago (Parin, 1986); recently, it has also been found off the Senegalese coast, where it was previously unknown (Capapé *et al.*, 2019).

R. pretiosus was discovered for the first time in the Mediterranean Sea off Messina, in the Strait of Sicily, and has been sporadically landed since in the fish markets of southern Italia (Tortonese, 1975). *R. pretiosus* is not reported from the Mediterranean coast of France (Quignard & Tomasini, 2000), but occurs in the Adriatic Sea, where it is considered as rather rare, mostly present in northern areas (Bettoso & Dulčić, 1999).

In the eastern Mediterranean, Tserpes *et al.* (2006), Peristeraki *et al.* (2008) and Kampouris *et al.* (2013) reported *R. pretiosus* in the Aegean Sea, and Golani (2005) off Israel. Conversely, El Sayed *et al.* (2017) did not report the species off the Mediterranean coast of Egypt, but westward, it was recorded for the first time in Libyan waters, off Benghazi (Elbaraasi *et al.*, 2007). Along the Maghreb shore, the species probably occurs in Morocco (Lloris & Rucabado, 1998), it has been reported from the Algerian (Refes *et al.*, 2010) and the Tunisian coasts (Ben Amor *et al.*, 2010). Routine monitoring conducted in this latter area and collaboration with experienced fishermen have allowed the observation of the *R. pretiosus* specimens described in the present paper, which also provides some comments concerning the species distribution in its new area.

MATERIAL AND METHODS

On 14 May 2020, a specimen of oilfish *Ruvettus pretiosus* was caught by longline, hooks baited with the European pilchard *Sardinella pilchardus* (Walbaum, 1792). The capture occurred in an area located off the north-western coast of Tunisia (Fig. 1), at a depth of 300 m, on rocky sandy bottoms, 36°46′55.22′ N and 11°30′11.90′ E, together with the white grouper *Epinephelus aeneus* (Geoffroy Saint-Hilaire, 1817), some scorpaenid species, the conger eel *Conger conger* (Linnaeus, 1758), the longnose spurdog *Squalus blainvillei* (Risso, 1826), and the brown ray *Raja miraletus* Linnaeus, 1758.

The total length and morphometric measurements were recorded to the nearest millimetre and total body weight to the nearest gram (Tab. 1). The specimen was fixed in 10% buffered formaldehyde, preserved in 75% ethanol and deposited in the Ichthyological Collection of the Institute des Sciences et Technologies de la Mer, Tunis-La Goulette, Tunisia, under the catalogue number INSTM Gem--rup-01.

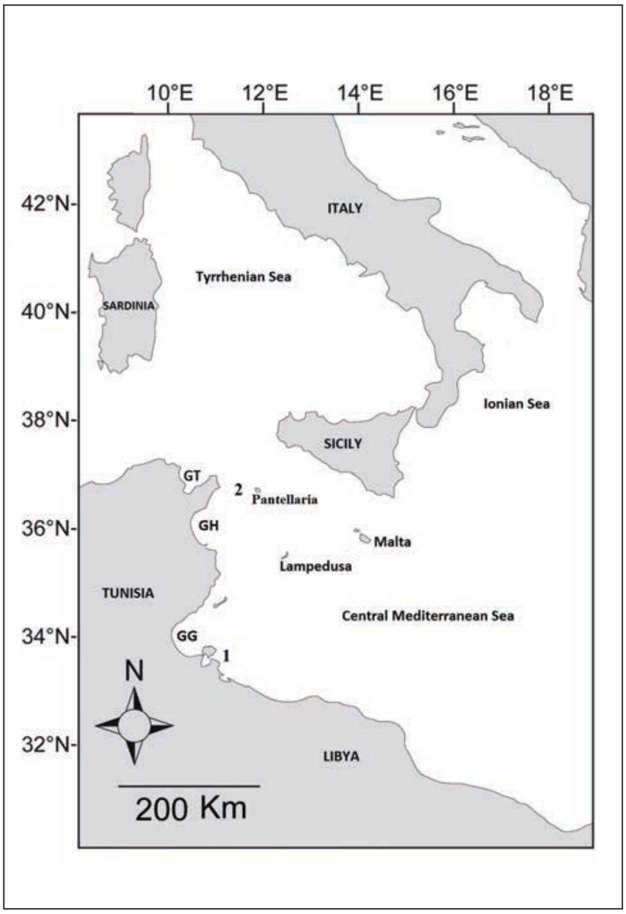


Fig. 1: Map of the central Mediterranean Sea, showing the Tunisian coast: 1. Capture site of the first recorded specimen of* Ruvettus pretiosus*, in the southern area (Ben Amor* et al.*, 2010). 2. Capture site of the second recorded specimen of* R. pretiosus*, in the northern area (present study). GG: Gulf of Gabès. GH: Gulf of Hammamet. GT: Gulf of Tunis.

Sl. 1: Zemljevid obravnavanega območja in tunizijske obale: 1. Lokaliteta ulova prvega primerka vrste* Ruvettus pretiosus *v južnem predelu (Ben Amor* et al.*, 2010). 2. Lokaliteta ulova drugega primerka vrste* R. pretiosus *v severnem predelu (pričujoča raziskava). GG: Gulf of Gabès. GH: Gulf of Hammamet. GT: Gulf of Tunis.

Tab. 1: The morphometric measurements, meristic counts, and total body weight of the oilfish** Ruvettus pretiosus **(ref. INSTM Gem-rup-01) caught from north--eastern Tunisian waters.

Tab. 1: Morfometrične meritve, meristična štetja in celotna telesna teža primerka vrste** Ruvettus pretiosus **(ref. INSTM Gem-rup-01), ujetega v severovzhodnih tunizijskih vodah.

Reference	**INSTM Gem-rup-01**	
Measurements	**mm**	**% TL**
Total length	1330	100
Standard length	1100	82.71
Forked length	1230	92.48
Head length	305	22.93
Eye diameter	52	3.91
Snout length	135	10.15
Pre-anal length	785	59.02
Pre-dorsal length	336	25.26
Upper jaw length	172	12.93
Pectoral fin length	149	11.2
Ventral fin length	92	6.91
Length of anal fin base	223	16.77
Body depth	23	17.29
Total body weight (kg)	25.1	
Counts		
First dorsal fin rays	XIV	
Second fin dorsal rays	16 + (2 finlets)	
Ventral fin rays	I-5	
Anal fin rays	II-14	
Caudal fin rays	17	

RESULTS AND DISCUSSION

The present specimen was identified as *Ruvettus pretiosus* via the combination of the following main morphological characters: body oblong, semi-fusiform and slightly compressed; snout rounded, not particularly produced; lower jaw extending slightly anterior to upper jaw, but rounded and with no conspicuous fleshy tip on either jaw, upper jaw reaching to mid-point of eye at least; two detached anal and dorsal finlets; caudal fin widely forked, without caudal keels; belly keeled by bony scales between pelvic fins and anus; small cycloid scales, interspersed with rows of sharp spiny tubercles; body uniformly brown to dark brown, but lighter brown on the sides and belly (see Fig. 2).

Main morphometric measurements, including percentages of total length (% TL) and meristic counts (see Tab. 1) agree with previous descriptions of this species (Tortonese, 1975; Parin, 1986; Nakamura & Parin, 1993; Ben Amor *et al.*, 2010; Capapé *et al.*, 2019) allowing us to note that the present capture constitutes the second substantiated record of *Ruvettus pretiosus* from the Tunisian coast. With 1330 mm in TL and weighing 25,100 g, it was slightly larger and heavier than the first record, which measured 1220 mm in TL and weighed 21,750 g. According to Parin (1986) the maximum size for oilfish is 2 m standard length, 3 m according to Nakamura & Parin (1993), for specimens from Pacific Ocean usually between 1000 and 1500 mm total length (Parin, 1986). Both specimens caught from the Tunisian coast could be considered as still juvenile.

Over a period of 12 years, only 2 specimens of *R. pretiosus* were caught in the Tunisian coast. The first capture occurred off Zarzis, southern Tunisia, at a low depth, although *R. pretiosus* preferentially inhabits deep and locally poorly exploited bottoms. Such scarcity of records indicates that the species is only sporadically caught in the area and this opinion was confirmed by information provided by local fishermen (Ben Amor *et al.,* 2010).

This second capture of *R. pretiosus* indicates the limit of the species' extension range in Tunisian waters and suggests a possible migration from southern towards northern areas. However, Tortonese (1975) noted that the core of the Mediterranean population of *R. pretiosus* is restricted to Italian seas and the northern Adriatic. Therefore, migration from the Italian seas to the northern Tunisian coast cannot be totally ruled out either. Conversely, Tserpes *et al.* (2006) noted that in Greek swordfish fishery the main bulk of by-catch is composed of oilfish. Therefore, occurrences of viable populations of *R. pretiosus* in some Mediterranean regions remain a suitable hypothesis. The scarcity of the species in local fish markets is probably due to the fact the species generally inhabits deep bottoms, which are poorly exploited. Additionally, the flesh of *R. pretiosus* is not particularly appreciated or widely used for human consumption due to its purgative effects if eaten in larger quantities (Nakamura & Parin, 1993). Therefore, the species has a low economical interest and is mainly discarded at sea.



Fig. 2: The** Ruvettus pretiosus **(ref. INSTM Gem-rup-01) caught in north-eastern Tunisian waters, scale bar = 200 mm. Insert showing the head of the same specimen, scale bar = 100 mm.
Sl. 2: Primerek vrste** Ruvettus pretiosus **(ref. INSTM Gem-rup-01), ujet v severovzhodnih tunizijskih vodah (merilo = 200 mm). Izrez prikazuje glavo istega primerka (merilo = 100 mm).

During the last few decades, several thermophilic species have appeared throughout Mediterranean due to the tropicalisation of the sea (Francour *et al*., 1994), affecting the Mediterranean ichthyofauna, in which several alien species seemed to have successfully established since the early 1900s according to Golani *et al*. (2017), after having migrated from the Red Sea (Lessepsian migrant, *sensu* Por 1978) and/or the eastern tropical Atlantic (Herculean migrant, *sensu* Quignard & Tomasini 2000). *R. pretiosus* appears to be more abundant off the western African coast and has been commonly observed in Senegalese fish markets, for instance (Capapé *et al*., 2019; Diatta, *pers. comm*. 2021). A possible Mediterranean recruitment of the species originating from these latter areas cannot be dismissed, even if it needs confirmation *via* further records.

DRUGI ZAPIS O POJAVLJANJU VRSTE *RUVETTUS PRETIOSUS* (GEMPYLIDAE) V TUNIZIJSKIH VODAH (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o drugem zapisu o pojavljanju redke vrste ribe kostnice, Ruvettus pretiosus *Cocco, 1833, iz tunizijskih voda. Primerek je meril 133 cm v dolžino in tehtal 25.1 kg. Ujeli so ga v severnem predelu Tunizije. Redkost te vrste na obravnavanem območju je verjetno posledica dejstva, da prebiva na bolj globokem in slabše izkoriščanem dnu, poleg tega ima nizko komercialno vrednost.*

Ključne besede: *Ruvettus pretiosus*, tunizijske vode, razširjenost, osrednje Sredozemlje, širjenje areala

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ON THE OCCURRENCE OF *SERIOLA FASCIATA* (CARANGIDAE) IN THE EASTERN MEDITERRANEAN SEA

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ABSTRACT

This paper reports on a record of Seriola fasciata *suggesting the extension of the species' distribution in the eastern Mediterranean Sea. On 8 September 2021, a single specimen of* S. fasciata *was caught by trammel net at a depth of 30–40 m off Yılancık Island, Marmaris, in the south-eastern Aegean Sea. This thermophilic fish is still very rare (about 24 specimens reported up to now) in the eastern Mediterranean Sea. The present is the second* S. fasciata *record for the Turkish Aegean Sea and the fourth for all Turkish seas.*

Key words: lesser amberjack, additional record, measurements, Yılancık Island, Aegean Sea

PRESENZA DI *SERIOLA FASCIATA* (CARANGIDAE) NEL MEDITERRANEO ORIENTALE

SINTESI

L'articolo riporta un ritrovamento di Seriola fasciata *che suggerisce l'estensione della distribuzione della specie nel Mediterraneo orientale. L'8 settembre 2021, un singolo esemplare di* S. fasciata *è stato catturato con un tramaglio ad una profondità di 30-40 m, al largo dell'isola Yılancık, Marmaris, nell'Egeo sud-orientale. Questo pesce termofilo è ancora molto raro (circa 24 esemplari riportati fino ad ora) nel Mediterraneo orientale. Questo ritrovamento è il secondo di* S. fasciata *per il Mar Egeo turco e il quarto per tutti i mari turchi.*

Parole chiave: ricciola fasciata, ulteriore ritrovamento, misurazioni, isola di Yılancık, Mar Egeo

INTRODUCTION

Seriola fasciata (Bloch, 1793) is spread both in the western Atlantic (from Massachusetts, USA, to Brazil) and in the eastern Atlantic (Madeira), but eastern Atlantic distribution is uncertain due to past confusion with *Seriola carpenteri* (Froese & Pauly, 2021). Being an Atlantic species, *S. fasciata* expanded its distribution range throughout the Mediterranean, from the Balearic Islands to Haifa Bay (Yapici & Filiz, 2020). This species entered the Mediterranean Sea through the Strait of Gibraltar, and Massuti and Stefanescu (1993) provided the first Mediterranean record from the Balearic Islands (Spain) in 1989. Thereafter, *S. fasciata* spread throughout the central and western Mediterranean (Golani *et al*., 2002). Sporadic catches of *S. fasciata* have occured since 1994 especially in Maltese coastal waters, primarily beneath fish-aggregating devices (FADs), such as palm fronds deployed in dolphin fish (*Coryphaena hippurus*) fishery, by means of trolling lines or angling from the shoreline (Andaloro *et al*., 2005). Andaloro *et al*. (2005) stated that the successive records of *S. fasciata* from west to east clearly show that the species successfully adapted to the warm waters of the southern Mediterranean and settled there gradually.

Lesser amberjack, *Seriola fasciata*, inhabits near-bottom or bottom zones between 55 m and 130 m of depth; large juveniles live in pelagic or benthic zones in shelf waters; smaller juveniles in the epipelagic zones of offshore neritic waters (Smith-Vaniz, 1986). The species feeds on squid and fish (Smith-Vaniz, 1986). Its maximum fork length (FL) is 675 mm, common length 500 mm TL, and the maximum published weight so far 4.6 kg (Froese & Pauly, 2021).

This paper presents a new and additional record of *S. fasciata* in a determinate area of the Turkish Aegean Sea, enhancing information about its distribution in the eastern Mediterranean Sea.

MATERIAL AND METHODS

On 8 September 2021, a single specimen of *Seriola fasciata* (Fig. 1) was captured on a sandy bottom by trammel net at a depth of 30–40 m, off Yılancık Island, Marmaris (coordinates 36º46.35 N - 28º25.58 E, Fig. 2) in the south-eastern Aegean Sea. The specimen was fixed in a 6% formaldehyde solution and deposited in the fish collection of Ege University, Fisheries Faculty (ESFM-PIS/2021-001).

RESULTS AND DISCUSSION

The specimen was measured to the nearest millimetre. It had a TL of 155 mm and weighed 59.6 g. The morphometric measurements as percentages of total length (TL%) and the meristic counts recorded in the *S. fasciata* captured from Yılancık Island, off



Fig. 1: *Seriola fasciata* ***caught off Yılancık Island, off Marmaris, SE Aegean Sea (ref. ESFM-PIS/2021-001, scale bar: 50 mm, photo: O. Akyol).***
Sl. 1: Primerek vrste *Seriola fasciata****, ujet blizu otoka Yılancık, Marmaris, JV Egejsko morje (ref. ESFM-PIS/2021-001, merilo: 50 mm, foto: O. Akyol).***

Tab. 1: Morphometric measurements as percentages of total length (TL%) and meristic counts recorded in the *Seriola fasciata* ***captured from the Aegean Sea.***
Tab. 1: Morfometrične meritve, označene v deležih glede na celotno dolžino (TL%), in meristična štetja na primerku malega gofa, *Seriola fasciata*, ***ujetega v Egejskem morju.***

Measurements	**Size (mm)**	**Proportion (TL%)**
Total length (TL)	155	
Fork length (FL)	139	89.7
Standard length (SL)	125	80.6
Maximum body depth	46	29.7
Pre-dorsal fin length	42	27.1
Pre-anal fin length	84	54.2
Pre-pectoral length	37	23.9
Head length	39	25.2
Eye diameter	9	5.8
Preorbitary length	11	7.1
Interorbitary length	16	10.3
Meristic counts		
1st Dorsal fin rays	VIII	
2nd Dorsal fin rays	I+28	
Anal fin rays	II, I+19	
Pectoral fin rays	I+19	
Ventral fin rays	I+5	
Weight (g)	59.6	

Marmaris, Aegean Sea are shown in Table 1. Short description: body oblong, moderately deep and slightly compressed. Two dorsal fins, the first small with eight spines, the last spine minute and embedded. Second dorsal fin with one spine and 28 rays. Anal fin with two small spines separated from the rest of the fin. The soft ray portion with 19 rays. Small pectoral fin with 20 rays. Ventral fin with one spine and five rays. Colour: Body background grey/yellow with eight dark bars. The first bar the darkest, the rest irregular and broken, the 4th to 8th extending into the dorsal fin. Dark spot at midpoint of caudal fin. First dorsal fin dark. Second dorsal, anal, and caudal fins with a touch of yellow. All the measurements, counts, proportions, and colour patterns determined are in accordance with the descriptions by Smith-Vaniz (1986), Golani *et al*. (2002), Deidun *et al*. (2011), Yapici and Filiz (2020), and Froese and Pauly (2021).

Seriola fasciata is gradually spreading towards the eastern basin of the Mediterranean. The literature-based recordings of *S. fasciata* throughout the Mediterranean are shown on a map in a recent study by Yapici and Filiz (2020). Additionally, in the eastern Mediterranean Sea, some *S. fasciata* have been reported intermittently; these are shown in Table 2.

The studied specimen was evidently juvenile. Smith-Vaniz (1986) specified that the juveniles are smaller than 20 cm FL. Thus, most records in Table 2 are juvenile recordings. This phenomenon suggests that there may be a spawning-stock biomass of *S. fasciata* in the eastern Mediterranean Sea.

Azzurro (2008) discussed the thermophilic fish species that expanded their distribution range in the Mediterranean basin, also including *S. fasciata*.

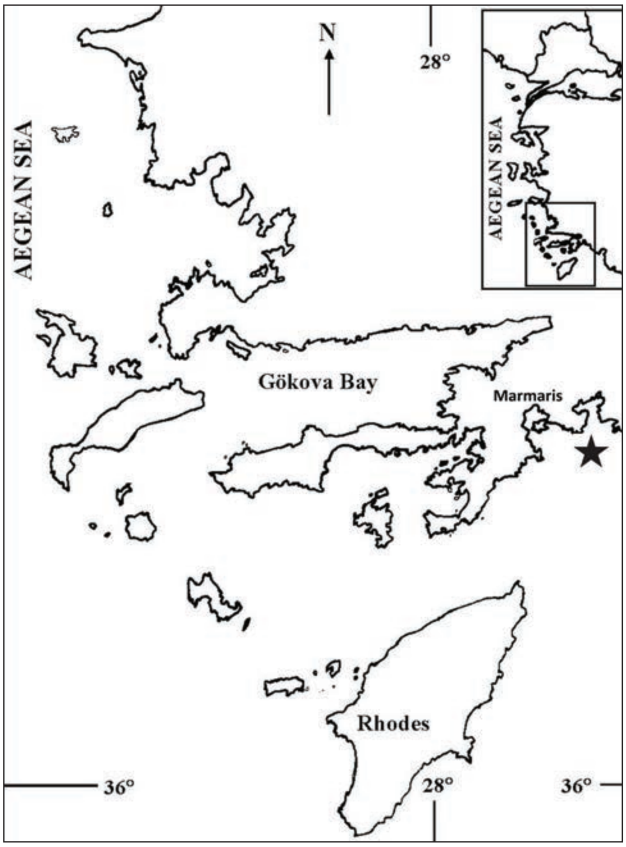


Fig. 2: Map showing the sampling site (black star) of *Seriola fasciata* ***in the Aegean Sea.***
Sl. 2: Zemljevid obravnavanega območja z označeno lokaliteto (črna zvezdica) najdbe vrste *Seriola fasciata* ***v Egejskem morju.***

Tab. 2: Intermittent records of* Seriola fasciata *in the eastern Mediterranean.
Tab. 2: Občasne najdbe malega gofa v vzhodnem Sredozemskem morju.

Area	Date	n	TL (mm)	Depth (m)	References
Ialissos-Trianda Bay, Rhodes	Nov. 2004	1	177	50-80	Corsini *et al.* (2004)
Haifa, Israel	12 Sep.2008	2	151a	?	Sonin *et al.* (2009)
Latakia, Syria	19 Oct.2013	1	148	15	Jawad *et al.* (2015)
Gulf of Antalya	25 Sep.2012	1	?	35-50	Kapiris *et al.* (2014)
Gulf of Antalya	19 Nov.2013	1	?	35-50	Kapiris *et al.* (2014)
Off Alexandria, Egypt	12 July 2017	15	120-170b	60	Stamouli *et al.* (2017)
Didim-Akbük, Aegean Sea	7 Oct.2018	1	301	30	Yapici & Filiz (2020)
Çevlik coast, İskenderun Bay	10 Nov.2018	1	183b	60-70	Doğdu et al. (2019)
off Marmaris, Aegean Sea	08 Sep.2021	1	139	30-40	This study

However, the thermophilic fish *S. fasciata* is still very rare (about 24 specimens reported up to now) in the eastern Mediterranean Sea. In conclusion, this paper on the occurrence of *S. fasciata* presents not only the second record for the Turkish Aegean Sea, but also the fourth record for all Turkish seas.

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O POJAVLJANJU VRSTE *SERIOLA FASCIATA* (CARANGIDAE) V VZHODNEM SREDOZEMSKEM MORJU

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POVZETEK

Avtorja poročata o najdbi vrste Seriola fasciata*, ki kaže na širjenje areala vrste v vzhodno Sredozemsko morje. Osmega septembra 2021 so v trislojno mrežo ujeli primerek vrste* S. fasciata *na globini med 30 in 40 m v vodah blizu otoka Yılancık, Marmaris, v jugovzhodnem Egejskem morju. Ta toploljubna vrsta je še vedno zelo redka v vzhodnem Sredozemskem morju (okoli 24 potrjenih primerkov doslej). Gre za drugi zapis o pojavljanju vrste* S. fasciata *v turškem Egejskem morju in za četrti zapis o pojavljanju v turških morjih.*

Ključne besede: mali gof, dodatni zapis, meritve, Yılancık Island, Egejsko morje

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AGE AND GROWTH OF THE POUTING *TRISOPTERUS LUSCUS* (LINNAEUS, 1758) (PISCES, GADIDAE) FROM MOROCCAN CENTRAL ATLANTIC WATERS

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ABSTRACT

This investigation, aimed to access the age and growth characteristics of the pouting, Trisopterus luscus *in the central Atlantic Moroccan coastal area, is based on otolith analysis. Age and growth of the population of* T. luscus *were studied on a total sample of 2210 individuals collected during monthly sampling from January 2018 to December 2019. The growth curves (length and weight) based on age estimates from otolith readings show that the greatest growth occurs during the first two years of life. The maximum age using the von Bertalanffy model is estimated to be 6 years (for both male and female pouting). The largest fish sampled (female) was 316 mm long. Different growth rates between males and females are shown; the average total length in females was equal to or greater than that in males, and the weight in female fish was always higher than that in males of the same year group.*

Key words: Age, growth, otoliths, *Trisopterus luscus,* Atlantic Moroccan coast

ETÀ E CRESCITA DELLA BUSBANA BRUNA, *TRISOPTERUS LUSCUS* (LINNAEUS, 1758) (PISCES, GADIDAE) DELLE ACQUE MAROCCHINE DELL'ATLANTICO CENTRALE

SINTESI

La ricerca, volta a studiare le caratteristiche di età e crescita della busbana bruna, Trisopterus luscus*, nella zona costiera atlantica centrale del Marocco, si basa sull'analisi degli otoliti. L'età e la crescita della popolazione di* T. luscus *sono state studiate su un campione totale di 2210 individui raccolti durante il campionamento mensile da gennaio 2018 a dicembre 2019. Le curve di crescita (lunghezza e peso) basate sulle stime di età dalle letture degli otoliti mostrano che la crescita maggiore si verifica durante i primi due anni di vita. L'età massima utilizzando il modello di von Bertalanffy è stimata a 6 anni (sia per il maschio che per la femmina). Il più grande pesce campionato (femmina) era lungo 316 mm. Sono stati evidenziati diversi tassi di crescita tra maschi e femmine; la lunghezza totale media nelle femmine era uguale o superiore a quella dei maschi, e il peso nelle femmine era sempre superiore a quello dei maschi dello stesso gruppo d'età.*

Parole chiave: età, crescita, otoliti, *Trisopterus luscus*, costa atlantica del Marocco

INTRODUCTION

Trisopterus luscus (Linnaeus, 1758) is a benthopelagic marine teleost living mostly in the outer Atlantic shelf area at depths about 100 m, but inshore shoals generally occupy depths up to 50 m and usually less in the spawning areas that include estuaries. Immature fish typically form large schools above sandy bottoms (Ballerstedt, 2008; Froese & Pauly, 2021). Distribution of the species extends from the Northeastern Atlantic – from Norway, along the coasts of Ireland and Britain, in the English Channel, in the North Atlantic coasts of France, Spain, Portugal, and the Atlantic Moroccan coast – to all parts of the western Mediterranean (62°N–25°N, 19°W–16°E) (Muus & Nielsen, 1999; Froese & Pauly, 2021).

Published data available on the growth of this fish species began with Chevey (1929) and Oliver (1949) in Chaves & Cardador (2004) and Froese & Pauly (2021). However, these studies were made using scales for estimating growth. Quadros Benvegnu (1971) researched biological aspects of the species on the Cantabrian coast, and Labarta & Ferreiro (1982) did similarly for Galicia. Gherbi Barre (1983), Desmarchelier (1986) and Puente (1988) provided information on the fish's general biology in the French seas. An age and growth study of *Trisopterus luscus* was also conducted off the coast of Asturias by Merayo (1994) and the species was also studied in Portuguese waters (Cardoso *et al.*, 2004). However, there is no information on the age and growth of the pouting in the Moroccan Atlantic, the southern limit of *Trisopterus luscus* in the eastern Atlantic (e.g., Chaves & Cardador 2004). The present biological study of growth in the pouting is the first related to the Atlantic Moroccan zone. Pouting are currently landed as bycatch by trawlers but they represent a significant share (in tonnage) of fish landed in the coastal ports of the Moroccan Atlantic, averaging about 1000 tons annually.

The purpose of this work is to establish the growth parameters of the sampled coastal population using linear, relative absolute weight growth analysis. A combination of these growth parameters together and the factors concerning reproduction and stock exploitation will help establish management measures for a rational stock exploitation to be proposed.

MATERIAL AND METHODS

Study Area

The study area (Moroccan Central Atlantic) extends from Essaouira in the north to Sidi Ifni to the south (Fig. 1) and includes the geographical south limit of the pouting stock distribution.

Biological sampling of the pouting stock made use of commercial catches of trawlers, long liners, and fishing canoes. Sampling was carried out over a 2-year period (2018 and 2019) at the main port in the Moroccan Central Atlantic region, the port of Agadir, where most of the fish catch in this area is landed. Sampling covered almost the entire size range of each pouting catch, which ranged between 11 and 31.6 cm in total length.

After extraction from the measured fish in the laboratory, otolith pairs were placed in labeled preservative tubes. The calcified parts were fixed within resin then cut using a small chainsaw and placed in numbered cells (Bedford, 1983; Merayo & Villegas, 1994; Cardoso *et al.*, 2004).

Age readings of the prepared otoliths were made under a binocular microscope (objective GR: X50) (Fig.2), using the whole otolith growth record (Holden & Raitt, 1975; Bedford, 1983).

Growth parameters were estimated using the von Bertalanffy (1938) model, Bertalanffy growth equation for length (mm): $\mathbf{L_t = L_\infty (1-exp^{(-k\,(t-t0))})}$, where Lt = the fish length according to the age at time t; L∞ = asymptotic length that would be reached by the fish at the infinite theoretical age; k = growth coefficient characterizing the speed with which the species grows towards its asymptotic size; t_0 = theoretical age for zero length.

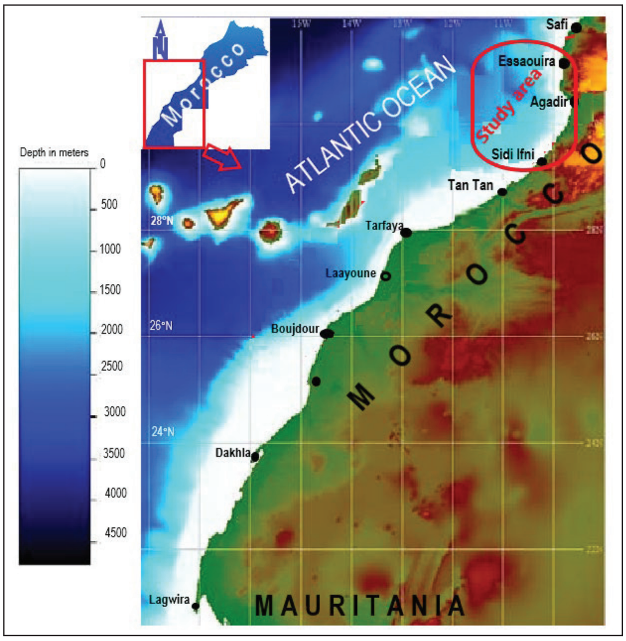


Fig. 1: Essaouira-Sidi Ifni sampling area and key fishing ports in the center and south Moroccan Atlantic regions.
Sl. 1: Vzorčevalni predel Essaouira-Sidi Ifni s ključnimi ribiškimi pristanišči v osrednjem in južnem delu maroške atlantske obale.

Tab. 1: Parameters of the von Bertalanffy equation for linear growth of *Trisopterus luscus* ***in the area of the Central Atlantic Moroccan coast.***
Tab. 1: Parametri von Bertalanffyijeve enačbe za linearno rast francoskega moliča *Trisopterus luscus* ***na predelu osrednje atlantske maroške obale.***

Parameters					Lenght	
Sex	**L∞**	**k**	**t0**	**Ø'**	**Lmin**	**Lmax**
Females	329.10	0.127	-4.02	4.14	131	316
Males	356.99	0.082	-5.21	4.02	113	278
Combined	359.69	0.105	-3.76	4.14	113	316

The von Bertalanffy growth equation for weight (g): $\mathbf{Wt = W\ (1\text{-}exp^{(-k(t-t0))})}$, where Wt = fish weight at the age of t (g); and W = asymptotic weight that would be reached by the fish at the infinite theoretical age.

The phi-prime test Ø′ (performance index) was used to compare the estimated linear growth parameters L∞ and k for both sexes and separated sexes, like in other studies.

The data used to determine the size-weight relationship of the pouting fish are total length (to the nearest millimeter) and weight (g). For the pouting, the mathematical formulation of the growth equation, expressing the evolution of average weights as a function of time, consists in simply combining the length-weight relationship with the size growth equation.

The expression of the length-weight relationship is exponential, as follows: $\mathbf{W = a\ L^b}$, where W = weight of fish in (g); L = total length of fish in (mm); a = proportionality constant (intercept) and, b = regression coefficient (slope). The association between total length (L) and total weight (W) was calculated by the correlation coefficient (r^2). Value of the exponent b provides information on fish growth. When b = 3, the increase in weight is isometric, otherwise it is allometric (major allometry if b > 3, minor allometry if b < 3). This size-to-weight relationship was calculated as logarithmic coordinates for both sexes taken together and for all individuals in the samples.

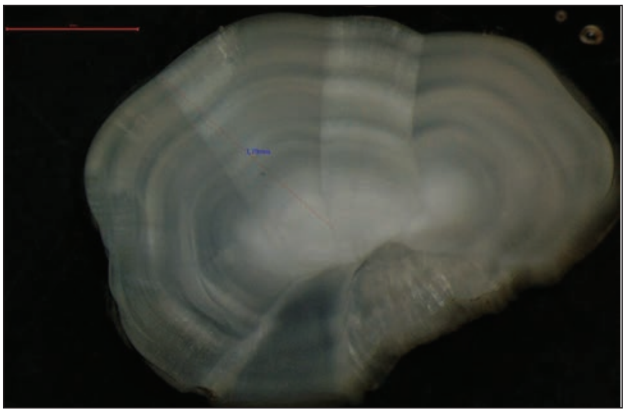


Fig. 2: Otolith of a *Trisopterus luscus* ***from the Moroccan Central Atlantic waters (scale = 1 mm).***
Sl. 2: Otolit vrste *Trisopterus luscus* ***iz osrednje atlantske maroške obale (merilo = 1 mm).***

Statistical analyses:

- The test "χ^2" was used for a comparison of growth in males and females;
- The test used to compare the growth parameters of the same species from the same stock or different stock is the phi-prime test (Ø′) (Munro & Pauly, 1983; Pauly & Munro, 1984) referred to as: Ø′ (phi prime) = log (K) + 2.log (L∞);
- The reliability of allometry was studied by the Student (t) test (Snedcore & Cochran, in Arneri *et al.*, 2001): t = (b – 3)/ (b); (b = allometric coefficient, (b) = standard deviation of b). The value of 't' obtained is compared to the theoretical 't' at the 5% threshold. A value greater than 't' theoretical indicates that there is allometry (b ≠ 3). If not, we have an isometry.

RESULTS

Length Growth

The linear growth of the pouting, according to the model of von Bertalanffy (1938), used the linear growth equation (L∞, k and t_0) and was estimated by the Gulland and Holt method considering the data for male and female fish separately and as a combination of both sexes (Choat *et al.*, 2006; Williams *et al.*, 2009). Consequently, the parameters for the linear growth equation of von Bertalanffy were also selected using data for both sexes of the pouting combined

Tab. 2: Statistical parameters for the comparison of the growth of *Trisopterus luscus* ***male-female in the area of the Central Atlantic Moroccan coast.***
Tab. 2: Statistični parametri za primerjavo rasti samcev in samic francoskega moliča *Trisopterus luscus* ***na predelu osrednje atlantske maroške obale.***

	χ^2 calculated	n	α	df	χ^2 observed
Male + Female	0.17	914	5%	6	1.64

*χ^2: chi-squared test; n: total numbers of individuals in the sample; α: alfa level 0.05 (5%); df: degree of freedom; χ^2 calcal = test χ^2 calculated; χ^2 observed = test χ^2 observed.

and for females and males separately (Tab. 1–3). The asymptotic lengths (to the nearest mm) obtained for the male and female pouting were 357 mm and 329 mm respectively, a difference of 27 mm. The asymptotic length ($L\infty$) of males was larger than that of the females and the growth constant (k) for the females was larger than those of the males.

Using the Von Bertalanffy equation (1938) for both sexes and for the sexes combined, theoretical size/age data pairs or size-age keys were calculated. These data pairs were used to draw a graphical representation of the length growth curve (Fig. 3). In general, the growth curve of a fish is asymptotic as described in the von Bertalanffy (1938) model. In our case, the lengths calculated by this model coincide with those observed (with slight differences). This suggests that the sample is representative of the size range of pouting present in the Moroccan Central Atlantic.

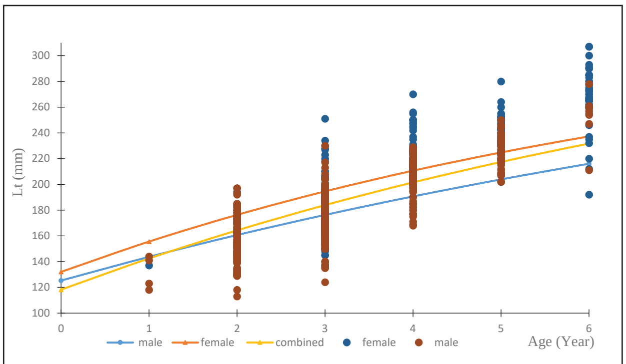


Fig. 3: Von Bertalanffy curves for the linear growth of the *Trisoprterus luscus* ***in the Central Atlantic Moroccan coast with data for male and female fish shown as colored points.***
Sl. 3: Von Bertalanffyjeve krivulje linearne rasti francoskega moliča *Trisoprterus luscus* ***iz osrednje atlantske maroške obale. Samci in samice so označeni z barvnimi krogci.***

Tab. 3: Age-length key obtained for *Trisopterus luscus* ***in the study area of the Central Atlantic Moroccan coast, for females, males and the two sexes combined.***
Tab. 3: Starostno-dolžinski podatki za samce in samice ter za oba spola francoskih moličev na vzorčenem predelu osrednje atlantske maroške obale.

Sex t(year)	Male (mm)	Female (mm)	Combined (mm)
0	125.28	132.01	118.21
1	143.70	155.56	142.45
2	160.65	176.30	164.26
3	176.26	194.56	183.88
4	190.63	210.63	201.53
5	203.,86	224.79	217.41
6	216.03	237.25	231.70

This curve allowed us to conduct a comparative examination of the growth of each sex. It shows that there is a significant difference between the male and female pouting in favor of the former in age group 0 (less than one year) (Tab. 3), beyond which the growth rate is reversed, in fact, the theoretical length at the same age is greater in females than in males during most of the life of the species. The age of the largest females and males observed in the study area was 6 years.

The linear growth curves for females, males, and both sexes of the pouting combined are shown in the graph (Fig. 3). The graph (Fig. 3) indicate that males initially grow faster than females. However, this difference only manifests itself in the first year of life and then always remains in favor of the females until theoretical year 9. The representation of von Bertalanffy's equations for the linear growth of the males and females of the pouting, on the same graph (Fig. 3) shows that the growth in length of the females is clearly faster than that of the males from the end of the first year of life. The length of female is then greater than that of the male.

Relative weight growth

In the 914 specimens of pouting caught in the Moroccan Central Atlantic during the study period of two years, the total length (L) varied between 113 mm (min. size) and 316 mm (max. size). The minimum weight in males was 14.3 g for a minimum size fish of 113 mm, in females it was 26.07 g for a

Tab. 4: Length-weight equation parameters in males and females of* Trisopterus luscus *from the area of the Central Atlantic Moroccan coast.
Tab. 4: Dolžinsko-masni odnos pri samicah in samcih francoskega moliča* Trisopterus luscus *iz predela osrednje atlantske maroške obale.

Sex	a	b	σ^2	r^2	n	L_{min} (mm)	L_{max} (mm)
Female	0.000008	3.0675	1.35	0.9656	512	131	316
Male	0.00001	2.9748	1.27	0.9612	402	113	278
Combined	0.000008	3.067	1.35	0.9678	914	113	316

*σ^2 = Variance

Tab. 5: Parameters for growth comparison in* Trisopterus luscus *male-female (Student t-test).
Tab. 5: Parametri za primerjavo rasti pri samicah in samcih francoskega moliča* Trisopterus luscus *(Studentov t-test).

Equation	Sex	a	b	r^2	n	χ^2 observ	Th(n-2) α =5%	Type of allometry
$W = a.L^b$	Female	0.000008	3.0675	0.9656	512	0.0497	2.02	Isometric
	Male	0.00001	2.9748	0.9612	402	-0.0198	2.02	Isometric
	Combined	0.000008	3.067	0.9678	914	0.0494	2.02	Isometric

*σ^2 = Variance

min fish size of 131 mm. The maximum total weight (Pt) was 430.49 g for a 316 mm female, compared to 303.84 g for a 278 mm male.

In order to determine the weight corresponding to all the calculated lengths, the size-weight relationships were determined for males, females, and the two sexes combined. We considered all couples, without prior grouping during the two cycles (2018/2019).

Figures 4 and 5 represent respectively the results of the variations in the relationship between total weight and total length for each sex and for all the individuals of the combined fish sample collected from the Moroccan Atlantic coast.

Tables 4 and 5 show the number of specimens collected, the minimum and maximum values of size, the estimated parameters a and b, as well as the correlation coefficient for the total weights. Irrespective of the size of the fish, the length and weight points are not dispersed, this indicates that the length-mass relationship is governed by the same correlation for all sizes. The R-correlation coefficients are very close to 1, reflecting a strong positive correlation between the two variables of size and weight.

The relationship between length (total length in mm) and body weight (g) was studied for the two sexes separately and combined (Tab. 5). The parameters of the equation are $W = a L^b$ (Ricker, 1980).

The estimated values of b are close to 3 regardless of sex (Tab. 6) and the Student t-test returns values below the 2.02 threshold, corresponding to a 95% degree of safety. This would suggest that in the pouting of either sex, as characterized by the isometric growth between the total weight and length, that body shape does not change significantly and that body development (weight growth) is proportional in both sexes.

The value of b (Tab. 6) is consistent and corresponds with the literature, which locates this value between 2.5 and 3.5 (Pauly,1997) for the size-weight relationships. The b parameter of the full-length-to-weight relationship, calculated for the two sexes of the pouting combined and separately, is roughly equal to 3, which shows a relative growth isometry. For males, the Student statistical test shows that factor b is less than ‘3,’ and therefore, the relative growth in the male and female pouting examined in the sample follows an isometric allometry function, meaning that weight and length increase proportionally.

The length-weight equations for the pouting examined are graphically represented in Fig. 4, for males, females, and the two sexes combined.

A comparison of equations from the length-to-weight relationship of males and females (Fig. 5) shows that at the same size, the full weight of the females is always greater than that of the males. The difference in weight in females compared to that in males is clearly observed above the size of around 180 mm total length, and is likely due to gonadal development, which is greater in females.

Absolute weight growth

The theoretical weight growth curves result from a combination of the linear growth equation $Lt = L_{\infty}(1 - e\ {-k}^{(t-to)})^{b}$ and the size-weight relationship ($W = a.L^{b}$). Applying the linear growth equation and the size-weight relationship, we follow the weight growth equation of Von Bertalanffy: $Wt = W_{\infty}(1\text{-}e\text{-}k^{(t-to)})^{b}$, where W, Asymptotic weights were established for both sexes separately and combined (Tab. 7). Parameters k and t_0 are identical to those calculated from the linear growth equation.

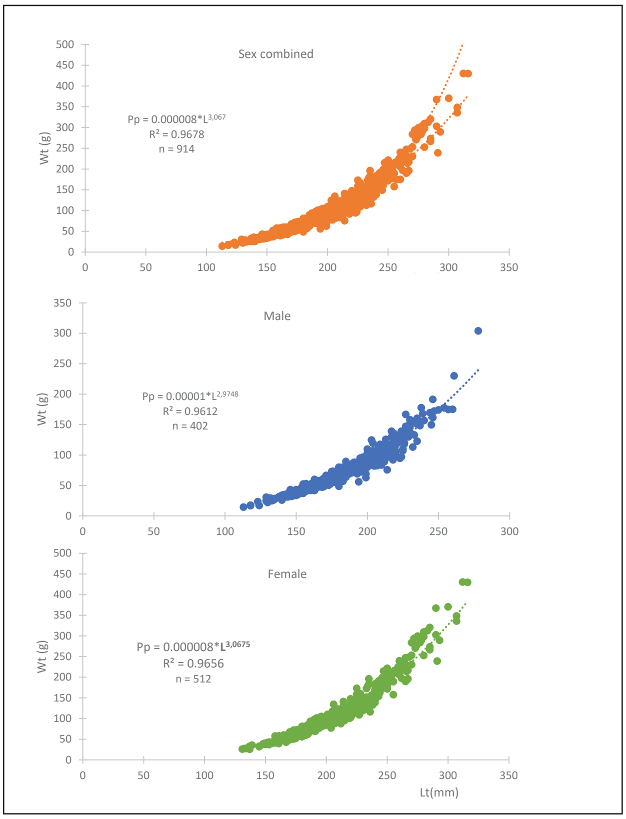


Fig. 4: Full (Pp) length (mm) – weight (g) relationship in *Trisopterus luscus* ***from the Moroccan Central Atlantic coast stock for the two sexes combined (top), males (center), and females (bottom).***
Sl. 4: Celotni masno-dolžinski odnos pri francoskem moliču *Trisopterus luscus* ***iz osrednje atlantske maroške obale za oba spola (zgoraj), samce (sredina) in samice (spodaj).***

The weight growth in females trends to an asymptotic value of 414.78 g, whereas in males the asymptotic weight is 385.04 g (Tab. 7 and Fig. 6). The asymptotic weights of females are comparatively much higher than those of males. Age-weight keys for females, males, and the sexes combined were calculated as the average weights for each category in years 0–1 to 6 (Tab. 8).

The average age-weight data are shown in the graph in Fig. 6 were weight growth in females is substantially greater than that of males, even in the age weight group of less than one year. The difference increases steadily to a maximum in individuals of the 6-year age group.

DISCUSSION

The linear growth of the Atlantic Moroccan pouting was studied using the modal progression method to demonstrate the distribution of length and weight data du-

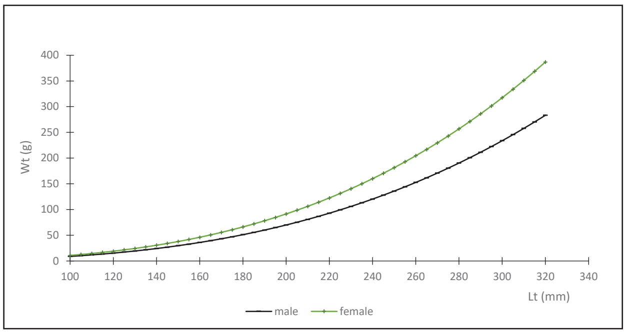


Fig. 5: Comparison of length equation curves – weight (g) of male and female *Trisopterus luscus* ***from the Central Atlantic Moroccan coast stock.***
Sl. 5: Primerjava krivulj na podlagi odnosa med dolžino in težo (g) samcev in samic francoskih moličev *Trisopterus luscus* ***iz osrednje atlantske maroške obale.***

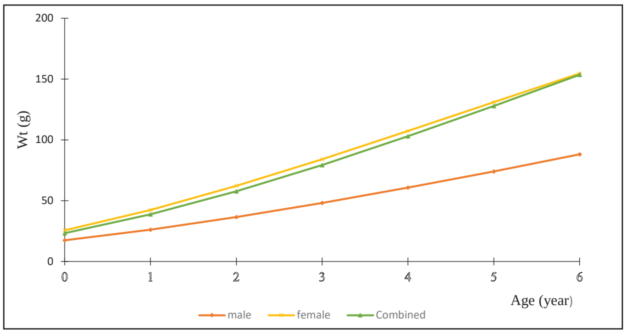


Fig. 6: Theoretical curves of the absolute weight growth of *Trisopterus luscus* ***in the area of the Central Atlantic Moroccan coast.***
Sl. 6: Teoretične krivulje za absolutno rast mase francoskih moličev *Trisopterus luscus* ***na predelih osrednje atlantske maroške obale.***

Tab. 6: Student t-test in length-weight allometry for the* Trisopterus luscus *of the area of the Central Atlantic Moroccan coast.
Tab. 6: Vrednosti Studentovega t-testa za dolžinsko-masno alometrijo pri francoskem moliču* Trisopterus luscus *na predelu osrednje atlantske maroške obale.

Sex	b	t. calcul	Allometry
Female	3.0675	0.0497	Isometric
Male	2.9748	-0.0198	Isometric
Combined	3.067	0.0494	Isometric

Tab. 7: Parameters of the absolute weight growth of* Trisopterus luscus *in the area of the Central Atlantic Moroccan coast.
Tab. 7: Parametri absolutne rasti mase francoskega moliča* Trisopterus luscus *na predelu osrednje atlantske maroške obale.

Sex	b	W∞(g)	k	t0
Combined	3.067	415.82	0.105	-3.76
Male	2.9748	385.04	0.082	-5.21
Female	3.0675	414.78	0.127	-4.02

ring the years 2018–2019. The von Bertalanffy equation is well suited for displaying linear growth trends in the separated and combined sexes of this fish in Moroccan Atlantic stocks.

This study revealed that growth rates for each sex decreased with age; they were highest at small sizes (2–3 years), while after 3 years of rapid growth of young individuals the rates declined, with the fish approaching asymptotic size and weight. The observations show that after the first year of growth, the female is always larger than the male and the rate of increase, be it weight or linear, is always higher in females than in males.

The difference in growth rate between the two sexes allows females to reach larger sizes than males at the same ages. Adjustment of growth parameters to von Bertalanffy's growth model (1938) shows that the growth constant values (k) for females are higher than those for males, while the females' asymptotic sizes (L∞) are smaller than the males'. Similar results were obtained by Puente (1988) in France.

Several hypotheses have been made to explain the dominance of females at larger sizes, including considerably higher mortality rates for males compared to those for females at the same ages, furtherly, but to a lesser extent, the difference in the growth rate between the two sexes, as well as access to fishing gear, and male vulnerability to environmental factors (Piñeiro & Sainza, 2003).

The phi-prime test Ø′ (performance index) was used to compare the estimated linear growth parameters L∞ and k for the combined sex and separated sex groups with those obtained in other studies. In general, the comparison of results showed only small differences in calculated Ø′. Ø′ values collected from bibliographic sources vary between 2.4 and 3. Thus, the growth parameters calculated in this study are above the range of the estimates made elsewhere since they vary from 4.02 to 4.14.

Differences between the Ø′ growth parameter estimated here may be explained by variations in the size range sampling data (Piñeiro & Sainza, 2003). Fish sample sizes are affected by seasonality (seasonal and interannual variation), and the otolith method of age reading can also affect estimated growth parameters (difficulties of differentiation between single and double rings can influence growth estimates). Differences in the characteristics of biogeographical zones such as dynamic hydro-climatic and environmental conditions are among other factors affecting the growth parameters (Pauly & Munro, 1984; Layachi *et al.,* 2007; Mellon-Duval *et al.,* 2010; Belhoucine, 2012; El Habouz *et al.,* 2014). Phi-prim values of Ø′ calculated using the same approach (otoliths, size distribution) are typically similar within the same study area, however, in

Tab. 8: Age-weight key obtained for* Trisopterus luscus *females, males and sex combined from the area of the Central Atlantic Moroccan coast.
Tab. 8: Starostno-masni podatki za samce in samice ter za oba spola francoskega moliča* Trisopterus luscus *na vzorčenem predelu osrednje atlantske maroške obale.

Sex T(year)	Female (g)	Male (g)	Combined (g)
0	17.40	25.59	23.26
1	26.18	42.34	38.81
2	36.48	62.15	57.73
3	48.07	84.09	79.34
4	60.69	107.28	102.94
5	74.09	130.97	127.85
6	88.05	154.55	153.48

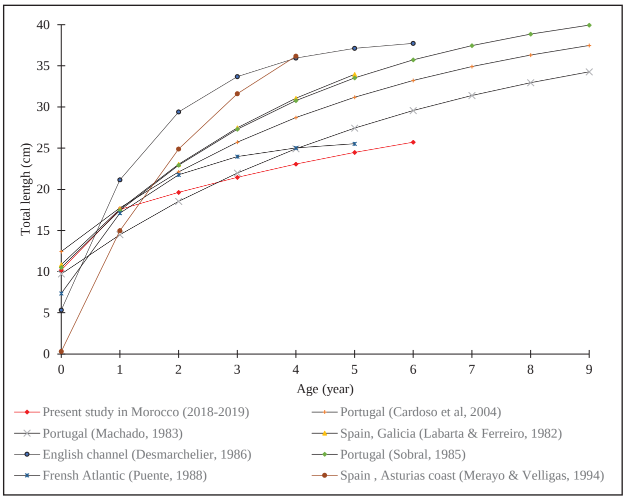


Fig. 7: Linear growth curves in the different *Trisopterus luscus* ***stocks according to different distributional areas.***
Sl. 7: Linearne rastne krivulje za različne populacije francoskih moličev *Trisopterus luscus* ***v različnih območjih razširjenosti.***

the Moroccan otolith study the Ø′ values remain higher than those in other Mediterranean and North Atlantic regions.

The Ø estimated for the higher latitudes (Atlantic France) is higher than that obtained in the Portuguese or Galician studies, indicating faster growth in the northern European region (Tab. 7). On the other hand, the phi-primes obtained in our study are higher than those reported in previous work (see Cardoso *et al.* (2004); Machado (1983); Labarta & Ferreiro (1982); Desmarchelier (1986); Puente (1988); Merayo (1994); Alonso-Fernández *et al.*, (2008)). The higher phi growth performance index (despite the maximum sizes of 31 cm in females) in the Moroccan study area may be due to the upwelling providing favorable conditions for the growth of this species. It should be noted that in the French and Spanish coastal zones, the growth curves established from the otoliths are superimposed, indicating a high degree of similarity between the two. The same result is also observed for curves drawn from the size distribution method and otolith measurements from the Portuguese coasts. The growth curve obtained here coincides with those obtained by Puente (1988) in the French Atlantic coast. The linear growth characteristics of pouting in the Moroccan Atlantic tests the hypothesis of the rapid growth that has been demonstrated elsewhere: in Portugal (Cardoso *et al.,* 2004; Sobral, 1985), in the Galician coasts (Labarta & Ferreiro, 1982), Asturian coasts (Merayo, 1994), in the English Channel (Demarchelier, 1988), and in the French Atlantic (Puente, 1988). Linear growth of the common pouting therefore appears to be faster in the North Atlantic (English Channel and the Asturian coastal areas) than in the Moroccan Atlantic, where the growth increase of the common pouting after year 2 is inferior to those established in previous studies (Fig. 7).

It should be noted that these earlier studies in the Spanish region report values by Labarta & Ferreiro (1982) and are not consistent with those of Merayo (1994). It is also noteworthy that the former used on average overall lengths lower than the average values obtained for young individuals (Merayo, 1994).

The value of the growth rate (k) obtained in this study is relatively low compared to previous studies of *T. luscus*. On the French coast (the Channel and the North Sea), the rates were k = 0.85 (male) and 0.66 (female) according to Desmarchelier (1986), and k = 0.52 (male) and 0.74 (female) according to Puente (1988) on the Aquitaine coast, and on the coast of Asturias, also by Puente (1988), k = 0.64 (male) and k = 0.53 (female). On the Galician coast, k was 0.21 (Labarta & Ferreiro, 1982), the value being almost the same as our results, k = 0.08 (male) and k=0.13 (female); our fish also reached a smaller maximum size than those in the previous studies. These differences may partly be due to the different methods used to estimate the growth parameters of fish from the Moroccan Central Atlantic, which grew more slowly than in other areas, reaching a smaller size at the same age.

It has been suggested that the pouting on the Galician coast exhibits slower growth but reaches a greater length age (9-year-old fish) (Labarta & Ferreiro*,* 1982) than the Cantabrian pouting, possibly because the colder conditions on the Galician coast provide a more favorable environment for this species. Other possible causes of the differences observed by Labarta & Ferreiro (1982) could be the interpretation of otolith data or the method of cutting otoliths and/or differences in the reading of otoliths (single or double rings).

Gherbi-Barre (1983) and Puente (1988) showed that on the French coast, the average lengths were only slightly lower compared to values obtained for the Spanish Asturian coasts. This suggests that growth increases meridionally along the Atlantic coastal zones from the north to the south.

This is supported by the representation of von Bertalanffy's equations for the linear growth of different regions on the same graph (Fig. 7), which show that the length growth of this species is faster in French and Spanish coasts compared to the south Atlantic.

With regard to the size-weight relationship curves, the observed peaks are very near the theoretical curve, which is explained by the fact that the values of the correlation coefficient are high. This demon-

Tab. 9: Methods used in male-female growth studies of** T. luscus **in different areas.
Tab. 9: Uporabljene metode za raziskave rasti samcev in samic vrste** T. luscus **v različnih predelih.

Area	Method	Authors	Sex	L cm	k	t_0	Ø′
Morocco	Otoliths	Present study	Males	35.6	0.08	-5.21	4.02
			Females	32.9	0.12	-4.02	4.14
			Combined	35.9	0.10	-3,76	4.14
Portugal	Otoliths	Cardoso et al. (2004)	Males	32.3	0.24	-2.03	2.4
			Females	43	0.19	-1.8	2.5
			Combined	43	0.16	-2.30	2.5
Portugal	Lenght freq	Machado (1983)	Combined	41.9	0.16	-1.65	2.4
Galicia (Spain)	Otoliths	Labarta & Ferreiro (1982)	Males	38.1	0.21	-1.16	2.5
			Females	46.4	0.21	-1.27	2.7
English Channel and North sea	Otoliths	Labarta & Ferreiro (1982)	Males	31.3	0.86	-1.21	2.9
			Females	38.4	0.65	-0.23	3
			Combined	35.1	0.65	-0.23	2.9
Portugal	Otoliths	Sobral (1985)	Males	38.4	0.19	-1.42	2.5
			Females	44.2	0.23	-1.18	2.6
French Atlantic	Otoliths	Puente (1988)	Males	33	0.52	-0.44	2.8
			Females	26	0.74	-0.45	2.7
Coast of Asturias	Otoliths	Merayo (1994)	Males	36.2	0.59	-0.014	-
			Females	45.7	0.39	-0.017	-
			Combined	40.2	0.48	-0.016	-

strates that the different equations used adequately reflect the relationships between the total fish weights and their total lengths. Comparison of the regression line slopes of the total length-weight relationship between male and female individuals shows that the relative growth in females is greater than in males.

This study shows that the larger female weight is related to the gonad weight. Our results coincide with those of Demarcheliers (1984) from the English Channel and Labarta & Ferreiro (1882) from the Galician coast; Merayo *et al*. (1986) made similar observations in relation to fish from the Asturian coast (Tab. 9).

A comparison between the slopes of the length-weight relationships, relative to value 3, allows us to point out that relative weight growth is isometric in both sexes. This tells us that weight growth is proportional to linear growth. The results of other authors related to growth parameters reported for different regions of the Mediterranean and the Atlantic are compared in Table 10. In general, the size-weight relationship in pouting (regardless of sex) obtained by this study is similar to those previously estimated in these other areas, and value (b) is statically approximately equal to 3 in both males and females of the central Moroccan Atlantic. This implies an "isometric" growth for both sexes of the species, as somatic growth is in proportion to increasing total length (see Tab. 8).

Divergence between some results could be closely related to the number of samples and the pairs of values considered for the calculation of the size-weight relationship, where coefficient b increases with the length of the fish (Tab. 10).

Overall, this study shows that weight measurement results clearly demonstrate differential growth rates between the two sexes of the pouting and that the females have a higher asymptotic weight than the males of the same size. The weight growth in the *T. luscus* of

Tab. 10: Size-weight relationship of* Trisopterus luscus *in different periods and areas.
Tab. 10: Odnos med velikostjo in maso pri vrsti* Trisopterus luscus *v različnih periodah in predelih.

Period and area	Authors	Sex	a	b	r²	t	Growth α = 0.01
Present study		Males	0.00001	2.958	0.997	0.0497	NS
		Females	0.000008	3.037	0.997	0.0198	NS
		Combined	0.000008	3.0097	0.986	0.0497	NS
1982 Galician Coast	Labarta & Ferreiro	Males	2.3*10-5	2.87			
		Females	2*10-5	2.95			
1986-87 Asturian	Merayo & Villegas	Males	0.000007	3.148	0.9836	0.145	NS
		Females	0.000008	3.112	0.992	0.076	NS
		Combined	0.000008	3.113	0.989	0.147	NS
1987-88 Asturian		Males	0.000012	3.048	0.990	0.0301	NS
		Females	0.000016	2.9889	0.990	-0.006	NS
		Combined	0.000014	3.017	0.990	0.0015	NS
1984 France	Desmarchelier	Males	1.25*10-3	3.002	0.976	-	-
		Females	9.61*10-3	3.090	0.956	-	-

the Moroccan Central Atlantic is in favor of females and these results are consistent with those obtained by Demarcheliers (1984) in the English Channel, and Labarta & Ferreiro (1882) and Merayo *et al.* (1986) in the Galician and Asturian coasts, respectively. Nevertheless, a comparison of the growth rates among pouting stocks in eastern Atlantic coastal seas shows differences in the methods used, indicating further work is required to harmonize the methodologies.

Our sample study on the growth characteristics of the Moroccan population of the pouting lays the foundations for further work on population dynamics and stock management of this species. It is suggested that the stock could become a sustainably managed fishery rather than exploited simply as bycatch. Whilst the pouting is not very appreciated by consumers, the larger fish do have the potential of becoming a more widely exploitable food resource if promoted and marketed attractively as an alternative to premium white fish.

CONCLUSIONS

Study of the growth biology of *Trisopterus luscus* in the Moroccan Atlantic coasts revealed that the length and weight growth rate of females is higher than that of males from the completed first year of life onwards. The linear growth analysis of this species tests the hypothesis of rapid growth age readings from otoliths which underestimates the growth of these fish. Weight-to-length changes in the pouting sample (regardless of sex) are constant and almost isometric, and in adults of equal size somatic weight gain by length is identical in both sexes, which supports the value of using otolith data. In the light of this preliminary research, which is the first of this kind in Morocco, it is recommended that more in-depth biological studies on this species should be carried out, including some on the growth-otolith measurement relationships and the population dynamics that would allow a better understanding of the stock dynamics and, potentially, facilitate fishery management as well.

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RAST IN STAROST FRANCOSKEGA MOLIČA *TRISOPTERUS LUSCUS* (LINNAEUS, 1758) (PISCES, GADIDAE) V ATLANTSKIH VODAH OSREDNJEGA MAROKA

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POVZETEK

Prispevek obravnava starost in rastne značilnosti francoskega moliča, Trisopterus luscus*, v osrednjem delu atlantske maroške obale na podlagi analize otolitov. Starost in rast populacije francoskih moličev sta bili raziskani na celotnem vzorcu 2210 primerkov, ujetih na mesečnih vzorčenjih od januarja 2018 do decembra 2019. Rastne krivulje (dolžina in teža), dobljene na podlagi ocene starosti iz preiskave otolitov kažejo, da se najvišja rast odvija v prvih dveh letih življenja. Z uporabo von Bertalanffyjevega modela so ocenili maksimalno starost na 6 let (za oba spola). Največji primerek je meril (samica) 316 mm v dolžino. Hitrost rasti se med spoloma razlikuje; povprečna dolžina je pri samicah enaka ali nekoliko večja kot pri samcih, teža samic pa je vedno večja od teže samcev v istih starostnih skupinah.*

Ključne besede: starost, rast, otoliti, *Trisopterus luscus,* atlantska maroška obala

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AGE AND GROWTH PARAMETERS OF THE RED MULLET *MULLUS BARBATUS* (MULLIDAE) FROM NORTHERN TUNISIA (CENTRAL MEDITERRANEAN SEA)

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ABSTRACT

The paper presents the results of a study of age and growth of the red mullet Mullus barbatus *Linnaeus, 1758 from the northern coast of Tunisia, based on otolith readings. The age composition ranged from 1 to 5 years, but the majority of specimens belonged to the one-year group, in both females and males. Females significantly outnumbered males in size classes larger than 150 mm, whereas males significantly outnumbered females in smaller size classes. Additionally, the growth patterns were similar up the age of 1 for both sexes, after which females grew faster and reached a greater maximum weight than males. The length-weight relationship was* $W = 0.0044 * TL^{3.1311}$ *(*$R^2 = 0.9582$*) for all specimens. Estimated growth parameters were* $L\infty = 24.23$, $K = 0.307$ *and* $to = -0.983$ *for males, and* $L\infty = 27.65$, $K = 0.284$ *and* $to = -0.687$ *for females. Estimates for all specimens display the following value:* $L\infty = 25.96$, $K = 0.291$ *and* $to = -0.824$*.*

Key words: *Mullus barbatus*, age, growth parameters, length–weight relationship, Tunisia

ETÀ E PARAMETRI DI CRESCITA DELLA TRIGLIA DI FANGO *MULLUS BARBATUS* (MULLIDAE) DELLA TUNISIA SETTENTRIONALE (MEDITERRANEO CENTRALE)

SINTESI

L'articolo presenta i risultati di uno studio sull'età e la crescita della triglia di fango, Mullus barbatus *Linnaeus, 1758, proveniente dalla costa settentrionale della Tunisia, basato sulla lettura degli otoliti. I risultati indicano che l'età degli esemplari varia da 1 a 5 anni, ma la maggior parte degli individui studiati appartiene al gruppo di un anno, sia le femmine che i maschi. Le femmine superano significativamente i maschi nelle classi di dimensioni superiori a 150 mm, mentre i maschi superano significativamente le femmine nelle classi di dimensioni inferiori. Inoltre, i modelli di crescita sono simili fino all'età di un anno per entrambi i sessi, dopo di che le femmine crescono più velocemente e raggiungono un peso massimo maggiore ai maschi. La relazione lunghezza-peso è* $W = 0{,}0044 * TL^{3{,}1311}$ *(*$R^2 = 0{,}9582$*) per tutti gli esemplari. I parametri di crescita stimati sono* $L\infty = 24{,}23$, $K = 0{,}307$ *e* $to = -0{,}983$ *per i maschi, e* $L\infty = 27{,}65$, $K = 0{,}284$ *e* $to = -0{,}687$ *per le femmine. Le stime per tutti gli esemplari mostrano il seguente valore:* $L\infty = 25{,}96$, $K = 0{,}291$ *e* $to = -0{,}824$*.*

Parole chiave: *Mullus barbatus*, età, parametri di crescita, rapporto lunghezza-peso, Tunisia

INTRODUCTION

The red mullet, *Mullus barbatus* Linnaeus, 1758 is a very important component of demersal fisheries in Tunisia (Chérif *et al*., 2007; Chérif *et al*., 2013). The species is commonly caught by trawl fleet and small-scale fishing vessels using trammel nets and gillnets, with this type of gear accounting for about 10% of catches (Chérif *et al*., 2013). During the last 10 years, the total annual landings stood at an average value of 2220 metric tons, representing 9.5% of total demersal catches (Anonymous, 2018). Despite the relative importance and economic value of the red mullet, the data on age and growth of this species in Tunisian waters, as opposed to other areas, are deficient. Gharbi (1980) studied the growth and age of *M. barbatus* based on an analysis of scale annuli, suggesting that the age determination from scales might be a source of errors in age-structured calculations and pointing out the need for the evaluation of age and growth using otolith microstructure analysis. Such opinion was in total accordance with similar studies of *M. barbatus* showing that otolith constitutes the most suitable structure for age estimation. While otolith readings are a reliable and valid method for age determination, the use of scales has been criticized mainly because the age in older specimens is frequently underestimated (Beamish & McFarlane, 1983; Carlander, 1987). Therefore, the main goal of this study is to present *M. barbatus* growth mark patterns based on an analysis of otolith microstructures.

MATERIAL AND METHODS

This study is based on material collected monthly from northern Tunisia (Fig. 1) between January 2005 and December 2007 by commercial trawlers using the Tunisian shrimp trawl with a stretched-mesh size of 52 mm in the wing and 40 mm in the cod end (Chérif *et al*., 2007). After landing, all specimens were measured for total length to the nearest millimeter, and for total body weight to the nearest gram. Additionally, they were sorted by sex. All sagittal otoliths were removed, cleaned and put in labeled envelopes. All otoliths were placed in a concave black dish and examined using the reflected light of a binocular microscope at a magnification of 10 X. The age estimates were obtained by each otolith being read at least twice by the same person. If the two age estimates did not coincide, a third reading was performed. When the three readings differed by one year, their median age was considered. However, when all three readings differed by more than one year, the otolith was discarded. In conclusion, the specimens examined in the present study ranged between 1 and 5 years of age.

The length-weight relationship was described by the form proposed by Ricker (1973): $W = aTL^b$, where (W) is the weight in grams, (TL) the total length in mm, (b) the growth exponent, and (a) is a constant. The hypothesis of isometric growth was tested using a *t-test* (Zar 1999).

Growth was expressed in terms following the von Bertalanffy equation (Beverton & Holt, 1957, Sparre & Venema, 1992): $L_t = L_\infty (1-e^{-k(t-t_0)})$, where ($L_\infty$) is the asymptotic total

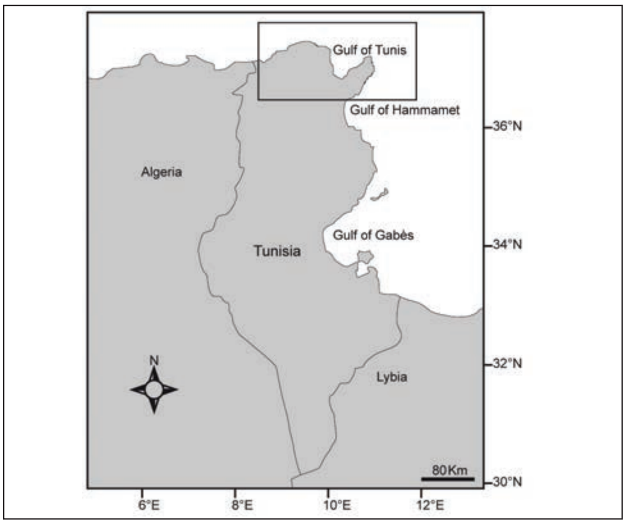


Fig. 1: Map of the Tunisian coast with the rectangle indicating the sampling area of** Mullus barbatus**.
Sl. 1: Zemljevid tunizijske obale z vzorčevalnim predelom (pravokotnik), kjer so vzorčili primerke bradačev** Mullus barbatus**.

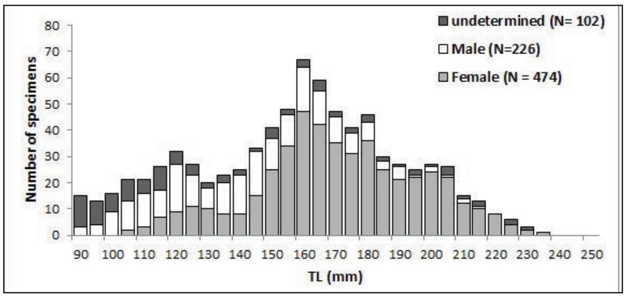


Fig. 2: Length frequency distribution in the** Mullus barbatus **caught from the northern coast of Tunisia.
Sl. 2: Frekvenčna porazdelitev dolžine primerkov vrste** Mullus barbatus**, ujetih ob severni tunizijski obali.

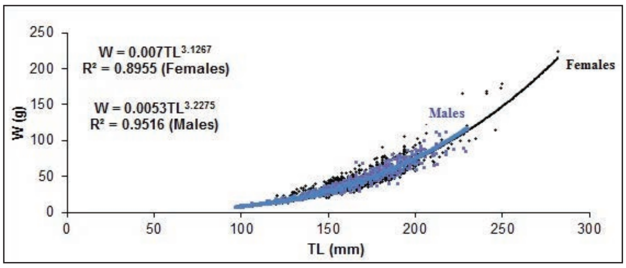


Fig. 3. Length-weight relationship in the** Mullus barbatus **caught from the northern coast of Tunisia.
Sl. 3: Odnos med dolžino in težo pri vrsti** Mullus barbatus**, ujeti ob severni tunizijski obali.

Tab. 1: Parameters of length-weight relationship for the** Mullus barbatus **caught from the northern coast of Tunisia.
Tab. 1: Parametri odnosa med dolžino in težo za primerke vrste** Mullus barbatus**, ujetih ob severni tunizijski obali.

Equations	Sex	a	b	R^2	t-test	Growth
W = aTL b	♀	0.0070	3.1267	0.8955	4.51	+
	♂	0.0053	3.2275	0.9516	7.99	+
	combined sexes	0.0044	3.1311	0.9582	20.02	+

Tab. 2: Age and growth parameters in the** Mullus barbatus **caught from the northern coast of Tunisia.
Tab. 2: Starost in rastni parametri pri vrsti** Mullus barbatus**, ujeti ob severni tunizijski obali.

Age (years)	Males (N = 132)	Females (N = 289)	All individuals (N = 488)
	TL (cm) (Average + SD)	TL (cm) (Average + SD)	TL (cm) (Average + SD)
I	11.16±0.9	11.32±1.3	11.25±0.4
II	14.30±1.1	15.44±1.7	14.87±0.9
III	17.25±1.4	19.40±0.9	18.32±1.0
IV	19.18±0.8	20.69±1.9	19.39±2.1
V	20.25±1.2	23.13±1.5	21.69±1.8
Growth parameters (L∞, W∞, K and t0)			
L∞ (cm)	24.23	27.65	25.96
K	0.307	0.284	0.291
to	-0.983	-0.687	-0.824
W∞ (gr)	148.88	240.72	198.64

length, (*Lt*) the total length at age (*t*), (*K*) the growth curvature parameter, and (*t0*) is the theoretical age of the fish at zero total length. For the growth in weight, the same function was used: $\mathbf{W_t = W_\infty\ (1\text{-}e^{-k\ (t\text{-}t_o)})}$, where (*Wt*) is the total weight, (*W∞*) is the asymptotic weight, and (*b*) is the power constant of the length-weight relationship. The Fishparm software including the non-linear estimation method was used to estimate the growth parameters (Saila *et al.*, 1988).

RESULTS

Length and weight distribution

Of the 802 fish examined, 226 were males, 474 females, and 102 unidentified (67 were immature and 35 damaged). The c2 test revealed that the difference between the sexes was significant (c2 =17.33; d.f =1; P <0.05).

The length and weight of the red mullet ranged from 94 mm to 237 mm in total length (TL) and from 7.64 grams to 148.17 grams in total weight (TW). The total length ranged between 103 mm in 237 mm (9.94 grams to 148.17 grams) in females and between 94 mm and 216 mm (7.64 grams to 110.24 grams) in males.

The dominant length group was 100–130 mm (23.2%), followed by 140–210 mm (69.4%) Females dominated size classes larger than 150 mm, whereas males significantly outnumbered females in smaller size classes (c2 =6.09; d.f =1; P <0.05). Evidently, the larger specimens caught were females (Fig. 2).

Length-weight relationship

The relationship between total weight and total length is presented in Table 1 and Figure 3. The value of (*b*) for males, females, and all specimens was significantly different from 3 (t-test, P < 0.05), indicating that the body shape displays positive allometric growth. In addition, the (R^2) values for relationships among males, females, and all fish indicated a good correlation between length and weight.

Age and growth parameters

The results of otolith readings for all fish, and separately for each sex are presented in Table 2 and Figure 4. Age was determined in 488 specimens (60.84% of total specimens). Five age classes were identified in each sex.

In females, age classes I (42.6%) and II (33.9%) were dominant, followed by age class III (15.3%). In males, the most dominant age class was I (1 year old) standing at 46.8%, followed by age class II (2 years old) at 37.3%. Length-at-age data obtained were used to calculate the von Bertalanffy growth parameters as follows (Fig. 3):

Males: $Lt = 24.23\ [1\text{-}e^{-0.307(t+0.983)}]$
Females: $Lt = 27.65\ [1\text{-}e^{-0.284(t+0.687)}]$
Sexes combined: $Lt = 25.96\ [1\text{-}e^{-0.291(t+0.824)}]$

Additionally, the growth patterns by sex were similar up to the age of 1 year (class I), after that age, the females grew faster and attained a greater maximum weight than males (Fig. 5).

DISCUSSION

Sagittal otoliths were used for age determination, showing that the age composition of the red mullet caught in the northern area of Tunisia ranged from 1 to 5 years. This result was in agreement with those of previous studies from different regions of the Mediterranean Sea (Jabeur, 1999; Çiçek, 2015). In the eastern and central Mediterranean Sea, the growth pattern was substantially different; the maximum observed life span for the red mullet was 9 years for all specimens (Genç, 2000; Carbonara et al. 2018). Furthermore, for the Black Sea, Aydin & Karadurmuş (2013) determined the age span to be between 1 and 7 years, while Sahin & Akbulut (1997) reported a maximum age of 6 years. Such differences are probably due to age estimation criteria, age estimation schemes, and material used, otolith or scale (Carbonara et al., 2018).

In this study the majority of the specimens belonged to classes I and II ndicating that the local *M. barbatus* population mostly included juvenile specimens. The lower proportions of adult specimens can be explained by the sampling method or by the fact that only some specimens are able to reach the maximum age. The (*b*) values of the length-weight relationship of *M. barbatus* differed largely according to localities (Table 3). These differences may be attributed to food availability (quantity, quality, and size), environmental conditions (temperature, salinity), sex, and stage of maturity (Ricker 1973; Pauly 1984; Sparre & Venema 1992; Chérif *et al.*, 2007; Yildiz & Karakulak, 2016; Carbonara *et al.*, 2018). Also, the sampling methods (commercial or survey), the different size structures, and the number of observed specimens in the studies could account for such differences of (*b*) values (Zorica *et al.*, 2006, Orhan & Genç, 2013; Carbonara *et al.*, 2018). A comparison of growth parameters of *M. barbatus* from the northern Tunisian coast with those from other areas of the world reveals significant differences (Tab. 3). The differences in growth rates between areas were probably due to differences in the methods of investigation, as well as latitudinal differences.

The present study seems to suggest that females grow slightly faster than males. This differential growth with respect to sex, displaying higher mean weights with age, may be explained by the distinct metabolisms of the two sexes (Pauly, 1994). Females accumulate hepatic lipids for metabolic functions, such as gonadic products, the phenomenon being more evident during vitellogenesis and egg production. Therefore, the difference in growth between males and females may be due to different stages in ontogenetic development, such as differences in condition and gonad maturity (Ricker, 1975; Morey et al., 2003).

In conclusion, recent studies note that stocks of *M. barbatus* have decreased off northern Tunisia (UNEP-MAP-RAC/SPA, 2014). Such patterns are probably due to overfishing and interspecific pressure for food. The results herein presented have shown that the most dominant age groups in the catches were between one and two years old. This indicates that the population was composed mostly by juvenile specimens, and faced a poor recruitment. Therefore, to prevent and avoid collapse in a long-term, the stocks of *M. barbatus* should be managed and exploited with care, being regularly restored in order to keep the presence of a viable population in the region.

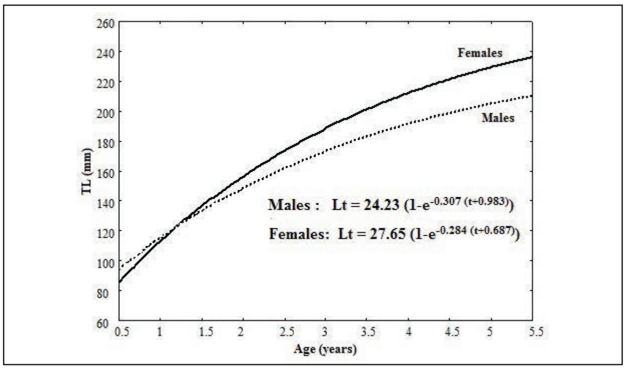


Fig. 4. Von Bertalanffy growth curve for the *Mullus barbatus* ***caught from the northern coast of Tunisia.***
Sl. 4: Von Bertalanffyjeva rastna krivulja za primerke bradačev *Mullus barbatus*, ***ujetih ob severni tunizijski obali.***

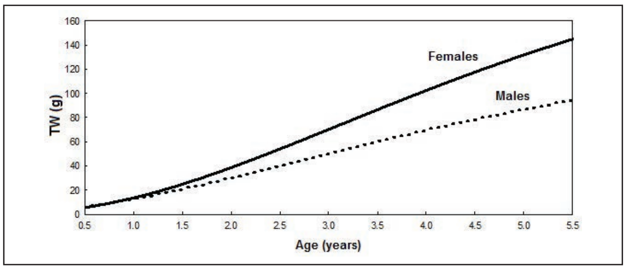


Fig. 5. Growth patterns by sex for the *Mullus barbatus* ***caught from the northern coast of Tunisia.***
Sl. 5: Rastni vzorci glede na spol pri vrsti *Mullus barbatus*, ***ujeti ob severni tunizijski obali.***

Tab. 3: Growth parameters (L∞, t0 and k) and length-weight relationship (a and b) for* Mullus barbatus *from different localities.
Tab. 3: Rastni parametri (L∞, t0 in k) in odnos med dolžino in težo (a in b) za primerke vrste* Mullus barbatus *iz različnih lokalitet.

Area	L∞ (cm)	t0	K	a	b	Reference
South-West Adriatic	19.7 TL	-1.180	0.36	0.008	3.09	Ungaro *et al.*, 1994
Adriatic Sea	27.49 TL	-0.25	0.5	-	-	Scaccini, 1947
Ionian Sea	25.20	–1.710	0.260	-	-	Tursi *et al.*, 1994
Izmir Bay	27 TL	-1.506	0.183	0.0063	3.363	Akyol *et al.*, 2000
Spanish coasts	33 TL	-0.07	0.38	-	-	Sanchez *et al.*, 1995
Northern Spain	33 TL	-0.001	0.33	0.006241	3.1597	Fernández *et al.*, 2005
Tunisian coasts	20.25 SL	-0.02	0.513	-	-	Gharbi, 1980
Greece waters	23.5 TL	-0.86	0.51	-	-	Vrantzas *et al.*, 1992
Izmyr Bay	19.036 FL	-0.77	0.438	0.0070	3.29	Kinacigil *et al.*, 2001
Aegean sea	24.2 TL	-5.61	0.105	0.0071	3.321	Őzvarol *et al.*, 2006
South-West Mediterranean	27 TL	-0.09	0.439	0.00009	3.031	Layachi, 2007
Iskenderun Bay	21.98 TL	-0.194	1.168	0.0072	3.162	Çiçek, 2015
Cyprus waters	28.4 TL	-1.100	0.18	0.01288	2.94	Livadas, 1988
Gulf of Tunis	-	-	-	0.0072	3.1045	Cherif *et al.*, 2007
Gulf of Tunis	-	-	-	0.005	3.23	Cherif *et al.*, 2008
Saranikos Gulf	23.5 TL	–0.860	0.51	-	-	Vrantzas *et al.*, 1992
Adriatic Sea	29.008 TL	–1.189	0.194	-	-	Carbonara *et al.*, 2018
Western Black Sea	-	-	-	0.0059	3.21	Türker & Bal, 2018
Middle Black Sea	-	-	-	0.0111	2.96	Kalaycı *et al.*, 2007
Western Black Sea	24.10 TL	-1.981	0.171	0.0109	2.9886	Yildiz & Karakul, 2016
Turkish coasts	24.4 TL	-0.716	0.450	0.01	3.001	Bingel, 1987
Aegean sea	19.13 TL	-1.56	0.382	0.0060	3.219	Tüzün *et al.*, 2019
Aegean sea	18.4 TL	-0.910	0.620	0.0100	3.201	Kurtul & Özaydın, 2017
Aegean Sea	28.75	–1.920	0.155	0.0084	3.077	Arslan & Işmen, 2014
Aegean Sea	26.08	–3.535	0.127	0.0157	2.981	Çelik & Torcu, 2000
Aegean Sea	19.04	–0.777	0.438	0.0071	3.290	Kınacıgil *et al.*, 2001
Iskenderun Bay	24.2	–0.569	0.63	-	-	Gücü, 1995
Black Sea	27.40	–2.351	0.140	0.0088	3.034	Aydın & Karadurmuş, 2013
Algerian Sea	25.09	-0.185	0.490	0.0172	2.842	Talet *et al.*, 2016
Northern Tunisia coasts	25.96 TL	-0.824	0.309	0.0044	3.131	This study

STAROSTNI IN RASTNI PARAMETRI PRI NAVADNEM BRADAČU *MULLUS BARBATUS* (MULLIDAE) IZ SEVERNE TUNIZIJE (OSREDNJE SREDOZEMSKO MORJE)

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POVZETEK

Avtorji poročajo o izsledkih raziskave o starostnih in rastnih parametrih pri navadnem bradaču Mullus barbatus *Linnaeus, 1758 iz severne tunizijske obale na podlagi analize otolitov. Starostna struktura je bila med 1 in 5 leti, večina primerkov, tako samcev kot tudi samic, pa je pripadala skupini prvoletnih rib. Samice so značilno prevladovale v velikostnih razredih večjih od 150 mm, samci pa so bili pogostejši v manjših velikostnih razredih. Vzorci rasti so bili pri obeh spolih podobni do starosti enega leta, potem pa so samice rasle hitreje in dosegle večjo maksimalno dolžino kot samci. Odnos med dolžino in težo za vse primerke je bil* $W = 0{,}0044 * TL^{3{,}1311}$ *(*$R^2 = 0{,}9582$*). Ocenjeni rastni parametri pri samcih so bili* $L\infty = 24{,}23$*,* $K = 0{,}307$ *in* $t_0 = -0{,}983$*, pri samicah pa* $L\infty = 27{,}65$*,* $K = 0{,}284$ *in* $t_0 = -0{,}687$*. Ocene rastnih parametrov za vse primerke so bile* $L\infty = 25{,}96$*,* $K = 0{,}291$ *in* $t_0 = -0{,}824$*.*

Ključne besede: *Mullus barbatus*, starost, rastni parametri, odnos med dolžino in težo, Tunizija

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HEAVY METAL CONCENTRATIONS IN TISSUES OF RED MULLET, *MULLUS BARBATUS* (MULLIDAE) FROM THE SYRIAN COAST (EASTERN MEDITERRANEAN SEA)

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ABSTRACT

Cadmium, lead and copper levels were measured in muscles and liver of red mullet Mullus barbatus *Linnaeus, 1758 caught off the Syrian coast between August 2019 and May 2020. It was found that the metals were accumulated in different tissues of* M. barbatus *by various levels, where the non-edible parts accumulated more metals than the edible muscles. The highest average levels of lead (0.164 ± 0.098 µg/g), and copper (8.69 ± 2.75 µg/g wet weight) were recorded in the liver. The concentrations of Cd, Pb, and Cu measured in edible muscle flesh were lower than the maximum acceptable limit set by FAO/WHO for human consumption. The order of the metal concentrations found in* M. barbatus *was Cu> Pb> Cd. Changes in metals concentrations in the tissues of* M. barbatus *were observed versus areas and seasons.*

Key words: Syria, heavy metals, *Mullus barbatus*, bioaccumulation, eastern Mediterranean Sea

CONCENTRAZIONI DI METALLI PESANTI IN TESSUTI DI TRIGLIA DI FANGO, *MULLUS BARBATUS* (MULLIDAE) LUNGO LA COSTA SIRIANA (MEDITERRANEO ORIENTALE)

SINTESI

I livelli di cadmio, piombo e rame sono stati misurati nei muscoli e nel fegato della triglia di fango Mullus barbatus *Linnaeus, 1758, catturata al largo della costa siriana tra agosto 2019 e maggio 2020. I metalli sono stati accumulati in diversi tessuti di* M. barbatus *in concentrazioni varie, e le parti non commestibili hanno accumulato più metalli che i muscoli commestibili. I livelli medi più alti di piombo (0,164 ± 0,098 µg/g) e di rame (8,69 ± 2,75 µg/g peso umido) sono stati registrati nel fegato. Le concentrazioni di Cd, Pb e Cu misurate nella parte muscolare commestibile erano inferiori al limite massimo stabilito dalla FAO/OMS per il consumo umano. L'ordine delle concentrazioni dei metalli trovato in* M. barbatus *era Cu> Pb> Cd. I cambiamenti nelle concentrazioni di metalli nei tessuti di* M. barbatus *sono stati osservati rispetto alle aree e alle stagioni.*

Parole chiave: Siria, metalli pesanti, *Mullus barbatus*, bioaccumulo, Mediterraneo orientale

INTRODUCTION

Five species are reported to date in the Syrian waters, two are indigenous species such as red mullet, *Mullus barbatus* Linnaeus, 1758 and striped red mullet *M. surmuletus* Linnaeus, 1758 (Saad, 2005; Ali, 2018) Three are alien species incoming from the Red Sea through Suez Canal into the Mediteranean Sea, as Lessepsian migrants (*sensu* Por, 1978), for instance golden-banded goatfish *Upeneus moluccenccis* (Bleeker, 1855), Por's goatfish *U. pori* Ben-Tuvia & Golani, 1989 and *Parupeneus forsskali* (Fourmanoir & Guézé, 1976). These three alien species are at present harvested in large quantities and sometimes more than the 2 indigenous mullid species, the best instance being *U. moluccensis* (Saad *et al*., 2017).

Mullid species constitute 3.1% of the number of bony fishes collected in the Syrian marine waters, and 8.9% of the total catch by artisanal fishing gears (Ullman *et al.,* 2015; Saad *et al.,*2017). Mullid species display a large economic value in the area because they are locally very appreciated for human consumption, and among them mainly *M. barbatus* (Saad & Sabour, 1998). This species is known as a bottom feeding carnivorous species at the top of the food chain (Saad & Sabour, 1998), and therefore could be expected that bio-accumulation levels of heavy metals rise.

A bioaccumulation of heavy metals in the different fish tissues has been previously studied (Saad & Hammoud, 2007; Mohamed, 2008; Turan *et al*., 2009; Abdallah, 2013; Aytekin *et al.,* 2019), also in *M. barbatus* showing that the species tissues accumulated high concentrations of heavy metals (Sunlu, 2004; Benedicto *et al*., 2007; Dural *et al*., 2010; Findik & Çiçek, 2011; Allan *et al.,* 2016). However, similar investigations have not been carryed out for specimens of *M. barbatus* from the Syrian waters which constitute the aims of the present papers in order to preserve human health of risk assessment.

The purpose of the present study consists to assess selected metal (Cu, Pb, and Cd) concentrations in muscles and liver of *M. barbatus* caught by commercial fisheries from three areas located on the coast of Syria.

MATERIAL AND METHODS

Study area

The sampling stations were selected based on main factors such as industrial effluents and sewageare being discharged into the waters of Syrian coast (Fig. 1). Therefore, three different sites were chosen. The first site (T1) was relatively close to industrial pollution sources (34°59'46» N, 35°53'21» E). The second site (T2) was performed based on its relation with the thermic power station activities (35°10'11» N, 35°55'36» E). The third site (T3) represents an area for the sewage downstream (34°53'09» N, 35°52'57» E).

Sample preparation and analysis

A total of 12 specimens of *M. barbatus* were studied, they were captured commercial bottom-trawler or gill net fisheriesfrom August 2019 to May 2020, at the 3 stations (Tab. 1). Total length (TL) was recorded to the nearest mm and total body weight (TBW) to the nearest 0.1 gram. TL ranged between 92 and 170 mm and TBW between 20.9 and 60 g.

The collected specimens were preserved in plastic boxes filled with ice, and then delivered at the laboratory. They were washed with distilled water, dried in filter paper and stored at -25°C until dissection. At about 3 gram sample of fish muscles

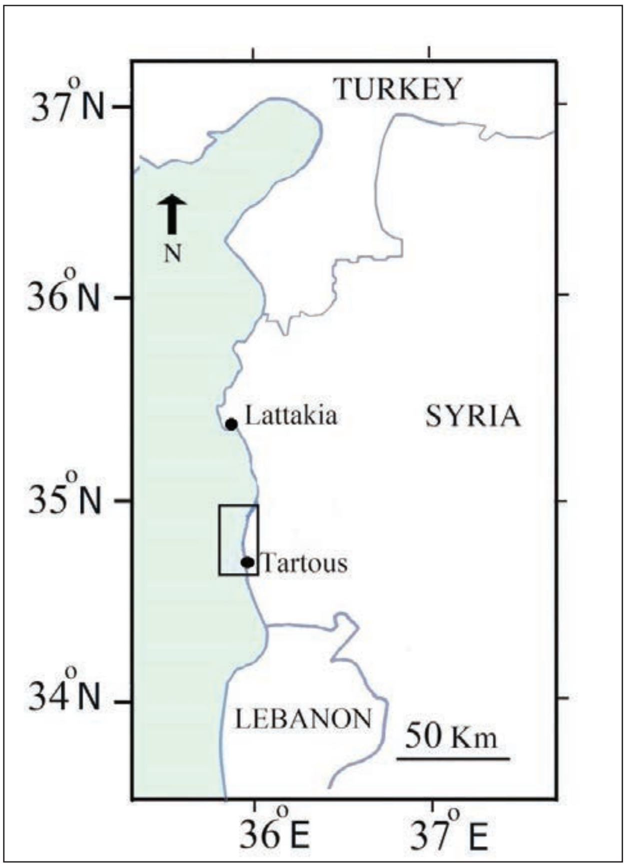


***Fig. 1: Map of the Syrian coast with rectangle indicating the sampling area of** Mullus barbatus.*
Sl. 1: Zemljevid sirske obale s pravokotnikom, ki prikazuje vzorčevalno postajo ulova bradačev.

Tab. 1: Minimum, maximum and mean metal concentrations in the tissues of the red mullet,** Mullus barbatus**, from the coastal waters of Syria and comparison of different sites (µg/g wet wt).
Tab. 1: Minimalne, maksimalne in srednje vrednosti koncentracij težkih kovin v primerkih bradača,** Mullus barbatus**, ujetih v obalnih vodah Sirije in primerjava med različnimi lokalitetami (µg/g mokre teže).

Tissue	Site	Mean	Cu Range	Mean	Pb Range	Mean	Cd Range
Muscles	T1	0.462	0.35-0.577 a	0.0281	0.018-0.038 a	0.0062	0.006 - 0.007 a
	T2	0.619	0.056-0.65 b	0.0651	0.05-0.074 b	0.0205	0.019-0.020 c
	T3	0.578	0.52-0.62 ab	0.0778	0.067-0.09 c	0.0172	0.015-0.018 b
Liver	T1	7.85	5.3-12.24 a	0.0497	0.031-0.07 a		-
	T2	8.91	5.69-12 a	0.193	0.18-0.21 b		-
		9.91	7.75-14 b	0250	0.23-0.27 c		-

Letters a, b and c show differences among sites. Means with the same letter are not statistically significant, p>0.05.

and part of liver, were removed. The wet digestion method was used in the analysis of the heavy metals (Saad & Hammoud, 2007; Abdallah, 2013; Turan *et al.,* 2019).

Samples were transferred into digestion flasks and treated with 5 ml HNO3 (ultrapure, Merck) on the hot plate until the color turns into light yellow, nearly white. After this process the samples were transferred to 25 ml flanks and added double distilled water until 25 ml. The solution was filtered by filter papers.

At each step of the digestion processes, acid blanks (laboratory blank) were prepared using identical procedure to ensure that the samples and chemicals used were not contaminated from any of the mentioned possible sources. They contain the same digestion reagents as the real samples with the same acid ratios but without the fish sample. They were analyzed by Atomic Absorption Spectrophotometer (Shimadzo-AA6800) before the real samples, to check if it will give the exact values of heavy metals in real samples.

Statistical analysis

Statistical differences between mean metal concentrations in different sites were evaluated using one way ANOVA. The difference between the seasons was analyzed through Student *t*-test.

RESULTS AND DISCUSSION

Heavy metals

Cu is the most abundant of metals examined (Tab. 1), it is an essential element since it plays important roles in biological systems (Kayhan *et al*., 2017). Conversely, lead and cadmium have caused harmful and toxic effects for human health even in trace amounts (Tepe *et al*., 2008). Copper concentrations ranged from 0.35 to 0.65 mg/g wet weight (ww) in muscle, the highest level occurring at station site T2, and from 5.30 to 14.00 mg/g ww in liver, with the highest level at site T3.

Copper concentrations vary significantly ($p<0.05$) in the muscle tissues, although copper concentrations in liver tissues did not show significant differences between T1 and T2 ($p>0.05$) (Tab. 1). Pb and Cd belong to nonessential, do not any function in biochemical processes.

This study shows that there were little variations in mean concentration of Cd and Pb in all sites investigated. In this study the mean Pb levels in muscle and liver were 0.0569 µg/g and 0.164 µg/g respectively (Tab. 1). Pb levels both in muscle and liver tissues showed significant differences between region. Mean Cd levels in the muscles of red mullet from T1, T2 and T3 from Syria were 0.0062, and 0.0172 mg/g, respectively. Cd levels in muscle tissues were statistically different between region. Pb and Cd concentrations were found higher in T3 and T2 station respectively. Our results show that metal accumulation is lowest in muscles , while it is high in liver in all sites. This probably due to their physiological roles in fish metabolism. Dural *et al*. (2010) determined that large amount of metallothione in induction occurs in the liver tissues.

Some authors have addressed measurements of Cu, Pb and Cd in fish from different regions of the world (Tab. 2). It appears differences between metal concentration in this study and those of previous studies. Copper concentrations in liver tissues found in this study were higher than those from Çandarl Bay. (Tas *et al.,* 2011), but displayed Copper concentrations in muscles tissues similar values than those of reported from Izmir Bay and Çandali Bay by Sunlu (2004) in Table 2. Cd concentrations have been less studied when than other metals in *M. barbatus* (Sunlu, 2004).

Tab. 2: Levels of heavy metals in *Mullus barbatus* ***from different areas of the world (µg/g wet weight)***
Tab. 2: Vsebnosti težkih kovin pri vrsti *Mullus barbatus* ***iz različnih predelov sveta (µg/g mokre teže).***

Tissue	Authors	Area	Cu	Pb	Cd
Muscles	Tas et al. (2011)	Çandarli Bay	0.11-1.25	1.20-9.74	-
	Sunlu (2004)	Izmir Bay	0.11-0.50	0.80-2.60	-
	Turan et al. (2009)	Black Sea	0.77-1.24	0.14-0.82	0.06-0.29
	Fındık & Çiçek (2011)	Black Sea	4.05	1.05	1.01
Liver	Tas et al. (2011)	Çanarli Bay	0.62 -2.09	5.30-12.52	-
	Mariji & Raspor (2007)	Eastern Adriatic	0.15-0.68	-	-
	Tepe et al. (2008)	Turkish seas	1.11-26.7	0.66-5.20	-

Seasonal variations in concentrations of metals in *M. barbatus*

Cupper contents in specimens *versus* seasons were different (Fig. 3). The mean Cu concentration in *M. barbatus* muscles from Syrian coast ranged between 0.51 / µg /g in rainy season and 0.59 mg/g in dry season and 7.39 to 10.45 at dry µg/g in liver (Fig. 2), and these values were significantly different (t-value = -3.07 , -4.80 ; p = 0.005; df = 1).

The mean Pb concentration in liver tissues did not show significant differences between season (Fig. 2). Conversely, the mean concentration of Pb in muscle of *M. barbatus* ranged from 0.049 mg/g to 0.0644 mg/g and show significant differences between seasons (Fig.3) (t-value = -4.34.; p = 0.007).

The mean Cd concentrations ranged from 0.006 at rainy to 0.022 at dry mg/g in muscle (Fig. 4). Cd levels in muscle tissues were not different between seasons (t-value = -1.66; p = 0.158). There was asignificant increase in accumulation of Cu, Pb, and Cd in tow tissues of *M. barbatus* from Syrian coast seasonally. The accumulation of metals in white muscle, and liver increased in dry season than rainy season this may be related to increase human activities in this seasons and increase in physiological activity of fish due to increase of temperature this confirmed by previous studies such as (Jakimska *et al.*, 2011). Similar increases in metal levels were observed during summer in fish species from Iskenderun Gulf (Aytekin *et al.*, 2019).

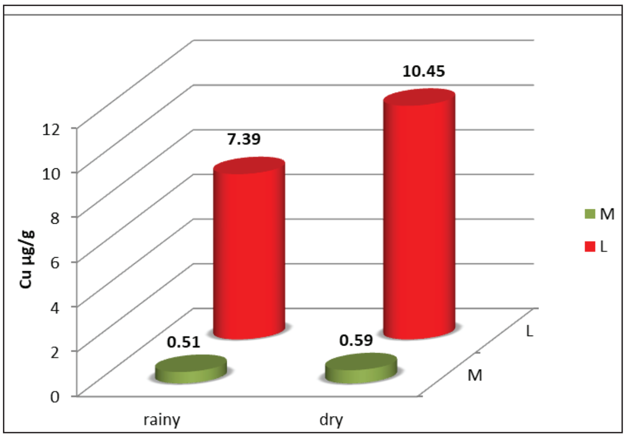


Fig 2: Differences of Cu concentrations in *Mullus barbatus* ***among the seasons: M = muscles, L = Liver.***
Sl. 2: Razlike v koncentraciji Cu pri vrsti *Mullus barbatus* ***v različnih sezonah: M = mišice, L = jetra.***

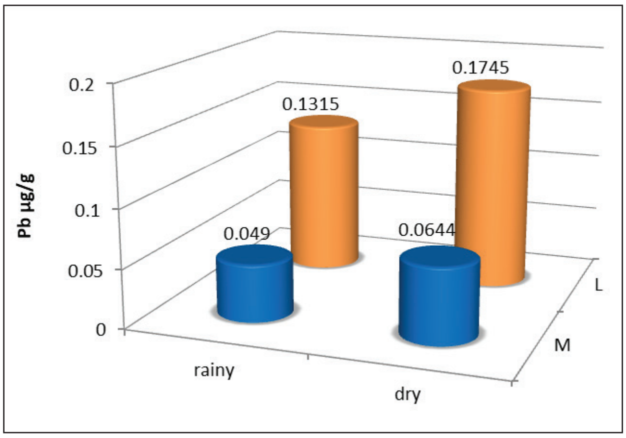


Fig 3: Differences of Pb concentrations in *Mullus barbatus* ***versus seasons.***
Sl. 3: Razlike v koncentraciji Pb pri vrsti *Mullus barbatus* ***v različnih sezonah.***

Human health risk assessment

Fish species are considered as one of the main protein sources of food for human health, because of having rich contents of essential minerals, vitamins and unsaturated fatty acids (Zaza *et al.*, 2015). In this study, the measured metal concentration in edible tissues , such as of *M. barbatus* were compared with some existing standards for human consumption.

From Marmara Sea, the levels of Cd and Pb were found as very high according to tolerance limits of the World Health Organization (WHO, 1996) standards (Kayhan *et al.,* 2017). For the fish samples from the Black Sea, Bat *et a*l. (2012) had been detected Pb and Cd levels lower than the recommended legal limits for human consumption according to the Turkish Food Codex (Anonymous, 2008). Chahid *et al.* (2014) determined the mean levels of Cd and Pb found in fish from Atlantic Sea (Morocco) as 0.009-0.036 mg /g for Cd and 0.013-0.014 mg/g for lead. The authors have concluded that these values fall within safe limits for human consumption.

Before the comparison, values were converted to mg/g wet weight. The mean muscle metal levels of *M. barbatus* were 0.553 mg/g for Cu, 0.0569 mg /g for Pb, and -0.0.014 mg/g for Cd. Mean values of Cu, Pb and Cd were below recommended limits of the Food and Agriculture Organization/World Health Organization (FAO/WHO, 2011): Cu: 30, Pb: 2 and Cd: 0.5 mg/g (ww). These values reached acceptable levels for human consumption and with any health problems for consumers. Additonally, such values recorded in *M. barbatus* showed that the Syrian marine waters are not strongly polluted by anthropogenic activites. However, these activities are generally located along the coast and underwent also ship dismantling and heavy ship traffic which could affect the aquatic species living in the area. Some species, as *M. barbatus* display a high commercial value, and regularly and frequently measurements of heavy metals should be done in these species generally consumed as food to avoid also a negative impact on the local economy.

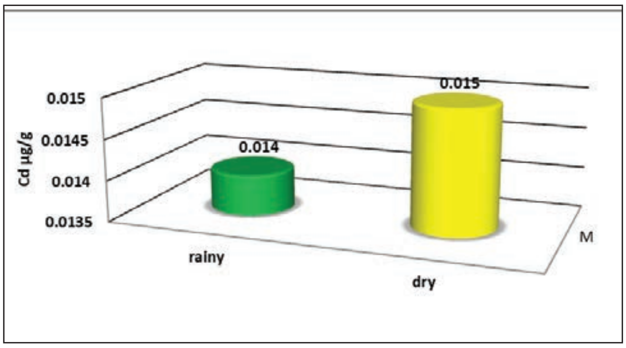


Fig 4: Differences of Cd concentrations in *Mullus barbatus* ***versus seasons.***
Sl. 4: Razlike v koncentraciji Cd pri vrsti *Mullus barbatus* ***v različnih sezonah.***

VSEBNOST TEŽKIH KOVIN V TKIVIH BRADAČA, *MULLUS BARBATUS* (MULLIDAE) IZ SIRSKE OBALE (VZHODNO SREDOZEMSKO MORJE)

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POVZETEK

Avtorji so v mišicah in jetrih primerkov bradača Mullus barbatus *Linnaeus, 1758, ujetih ob sirski obali avgusta 2019 in maja 2020, merili vsebnost kadmija, svinca in bakra. Ugotovili so, da so se težke kovine kopičile na različnih nivojih in v različnih tkivih bradača, pri čemer je se je več težkih kovin nakopičilo v neužitnih delih bolj kot v užitnih mišicah. Najvišje povprečne vrednosti svinca (0,164 ± 0,098 μg/g), in bakra (8,69 ± 2,75 μg/g mokre teže) so bile izmerjene v jetrih. Vsebnost Cd, Pb in Cu, izmerjena v užitnem mesu mišic, je bila nižja kot maksimalna dovoljena vrednost po kriterijih FAO/WHO za človeško uporabo. Redosled koncentracije težkih kovin v bradaču je bil Cu> Pb> Cd. Spremembe v koncentraciji težkih kovin v tkivih bradača so primerjali v različnih okoljih in različnih sezonah.*

Ključne besede: Sirija, težke kovine, *Mullus barbatus*, bioakumulacija, vzhodno Sredozemsko morje

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RECORD OF A SINGLE CLASPER SPECIMEN IN *ZANOBATUS SCHOENLEINII* (CHONDRICHTHYES: ZANOBATIDAE) FROM THE COAST OF SENEGAL (EASTERN TROPICAL ATLANTIC)

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ABSTRACT

The authors report on the capture of an abnormal specimen of striped panray, Zanobatus schoenleiniii *(Müller & Henle 1841) from the coast of Senegal. The specimen measured 250 mm in disc width (DW) and weighing 621 g in total body weight (TBW). It exhibited a lack of the right clasper, already visible from the view of the dorsal surface, and an undeveloped and reduced pelvic fin, especially in its distal margin. The dissection of the abdominal cavity showed on both sides a genital apparatus morphologically male and almost similar. The lack of any female structure allows to state that this present specimen didn't display a case of pseudo or true hemaphroditism , but rather a case of morphological abnormality.*

Key words: batoid species, lack of clasper, morphological abnormality, coast of Senegal

RITROVAMENTO DI UN ESEMPLARE DI *ZANOBATUS SCHOENLEINII* (CHONDRICHTHYES: ZANOBATIDAE) CON UN SOLO PTEROPODIO LUNGO LA COSTA DEL SENEGAL (ATLANTICO TROPICALE ORIENTALE)

SINTESI

Gli autori riportano la cattura di un esemplare anomalo di Zanobatus schoenleiniii *(Müller & Henle 1841) lungo la costa del Senegal. L'esemplare misurava 250 mm di larghezza del disco (DW) e aveva 621 g di peso corporeo totale (TBW). Presentava una mancanza del pterigopodio destro, notabile già alla vista della superficie dorsale, e una pinna pelvica non sviluppata e ridotta, specialmente nel suo margine distale. La dissezione della cavità addominale ha mostrato su entrambi i lati un apparato genitale morfologicamente maschile e quasi simile. La mancanza di una struttura femminile permette di affermare che questo esemplare non mostrava un caso di pseudo o vero emafroditismo, ma piuttosto un caso di anomalia morfologica.*

Parole chiave: specie batoide, mancanza di pterigopodio, anomalia morfologica, costa del Senegal

INTRODUCTION

The striped panray, *Zanobatus schoenleiniii* (Müller & Henle, 1841), is an endemic species known from the eastern tropical Atlantic, from southern Morocco (Lloris & Rucabado, 1998) to the Gulf of Guinea (Blache *et al.*, 1970), captured by handicraft fisheries, especially throughout the coast of Senegal in shallow coastal waters at low depth, not exceeding 50 m depth (Capapé *et al.*, 1995). These captures allowed to provide preliminary data about some traits of reproductive biology and feeding habits of the species (Capapé *et al.*, 1995). Among the collected *Z. schoenleinii* some abnormal specimens were found and formed the object of papers (see Tab. 1). Additionally, an other abnormal specimen was recently discovered and described in the present paper.

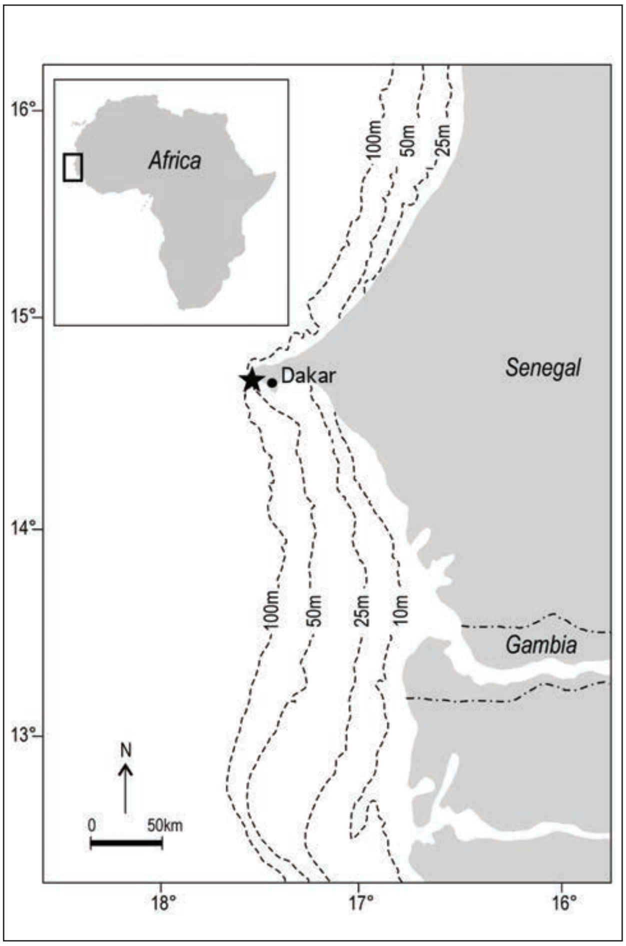


Fig. 1: Map of the Senegalese coast indicating the capture site of the abnormal specimen of** Zanobatus schoenleinii **(black star).
Sl. 1: Zemljevid senegalske obale z označeno lokaliteto, kjer je bil ujet neobičajen primerek vrste** Zanobatus schoenleinii **(črna zvezdica).

MATERIAL AND METHODS

A total of 33 specimens of *Z. schoenleinii* were captured off Dakar, located in Cape Verde Peninsula, and collected at the fishing site of Hann on 11 December 2020. They were caught by commercial trammel net made of threee layers of mesh, having a streched size of 48 mm, 50 mm and 60 mm, respectively, at a depth between 5 and 16 m, on sandy-muddy bottom, together with other telost species, by 14°43’32.1» N and 17°25’35.4» W (Fig. 1). Of the 33 specimens, 32 were normal and a single specimen displayed a lack of clasper.

All specimens were measured to the nearest millimetre for disc width (DW) and weighed to nearest gram for total body weight (TWB). Morphometric measurements were recorded on the abnormal specimen following Diatta *et al.* (2013) and presented in Table 1. The specimen was fixed in 10% buffered formaldehyde, successively preserved in 75 % ethanol and deposited in the Ichthyological Collection of the Institut Supérieur d’Aquaculture et de Pêche of Bizerte (Tunisia), with the catalogue number, ISPAB-Zan-sch-09.

The relation between DW and TBW was used as a complement following Froese *et al.* (2011), including all specimens, normal and abnormal to show if this latter is able to develop in the wild as normal specimens. This relation is TBW = aDW^b, and was converted into its linear regression, expressed in decimal logarithmic coordinates and correlations were assessed by least-squares regression. as: log TBW = log a + b logDW. Significance of constant b differences was assessed to the hypothesis of isometric growth if $b = 3$, positive allometry if $b > 3$, negative isometry if $b < 3$ (Pauly, 1983). These two latter tests were performed by using logistic model STAT VIEW 5.0.

RESULTS AND DISCUSSION

All specimens were identified as *Zanobatus schoenleinii* as follows: morphological characters: disc subcircular, wider than long; snout blunt, angle nearly 120° in front; nostrils narrow, anterior valves united across the internarial space; mouth straight with small teeth; spiracles large without folds; dorsal and caudal fins small and rounded; covered by a rigid skin, unlike and minute scales, a medial row of thorns in disk and tail, and a three rows arranged in arc of circle on each shoulder; back brown with dark cross bands with white spots between toward the pectoral edges. Such description is in total agreement with Garman (1913), Cadenat (1951), Blache *et al.* (1970) and Capapé *et al.* (2020a, b).

Southward, a new congeneric species was described in the area *Zanobatus maculatus* Séret, 2016. Which displays a smaller size panray, disc more rounded, rhombic in the striped panray; exhibiting numerous dark brown blotches of various sizes vs. wavy medium brown

Tab. 1: Morphometric measurements (in mm and as % DW), meristic counts and mass recorded in the abnormal specimen of* Zanotatus schoenleinii *(ISPAB-Zan-sch-09).
Tab. 1: Morfometrične meritve (v mm in kot delež premera diska % DW), meristična štetja in masa neobičajnega primerka vrste* Zanotatus schoenleinii *(ISPAB-Zan-sch-09).

REFERENCES	**ISPAB-Zan-sch-09**	
Measurements	mm	% Disc width
Total length	455	182.00
Disc length	235	94.00
Disc width	250	100.00
Disc depth	34	13.60
Eyeball length	14	5.60
Pre-orbital length	49	19.60
Inter-orbital length	22	8.80
Spiracle diameter	21	8.40
Interspiracular width	27	10.80
Space between eye and spiracle	11	4.40
Pre-oral length	52	20.80
Mouth width	33	13.20
First gill-slit	7	2.80
Second gill-slit	9	3.60
Third gill-slit	8	3.20
Fourth gill-slit	8	3.20
Fifth gill-slit	6	2.40
Width between first gill-slit	64	25.60
Width between fifthgill-slit	35	14,00
Snout tip to eye	62	24.80
Snout tip to mouth	60	24.00
Snout tip to first gill-slit	90	36.00
Snout tip to fifth gill-slit	119	47.60
Snout tip to vent	202	80,80
Pectoral fin anterior margin	160	64,00
Pectoral fin posterior margin	141	56.40
Pectoral fin inner margin	14	5.60
Pelvic fin anterior margin	37	14.80
Pelvic fin posterior margin	54	21.60
Pelvic fin inner margin	24	9.60
Span of pelvic fins	99	39.60
Clasper length	45	18.00
First dorsal anterior edge	39	15.60
First dorsal posterior edge	26	10.40
First dorsal inner edge	7	2.80
Second dorsal inner edge	7	2.80
Interdorsal distance	27	10.80
Second dorsal to caudal birth	24	9.60
Total body weight in gram	621	



Fig. 2: Abnormal specimen of* Zanotatus schoenleinii *(ISPAB-Zan-sch-09). A. Dorsal surface. B. Ventral surface. Scale bar = 50 mm.
Sl. 2: Neobičajen primerek vrste* Zanotatus schoenleinii *(ISPAB-Zan-sch-09). A. Hrbtna stran. B. Trebušna stran. Merilo = 50 mm.

crossbars; a dermal armature more pronounced, and has spear-shaped dermal denticles vs. polygonal flat denticles and smaller number of tooth rows, probably due to its smaller size.

The sampled specimens ranged between 154 and 270 mm DW and their TWB from 104 to 914 g. The abnormal specimen measured 250 mm DW and weighed 621 g, and it exhibits a lack of the right clasper, already visible from the view of the dorsal surface (Fig. 2A). An examination of the ventral surface displays the presence of a left clasper developed but still flexible, characteristic from a juvenile specimen (see Capapé *et al.*, 1995). The right pelvic area exhibits a total lack of clasper and an undeveloped and reduced pelvic fin, especially in its distal margin. No unhealed scar were observed on this distal margin, conversely it was pigmented and covered by small denticles. This reduced pelvic fin is not consequence of an injury caused by a predator but a morphological abnormality probably occurring durig the embryonic development, rarely after birth , in the wild.

The dissection of the abdominal cavity shows on both sides a genital apparatus morphologically male and almost similar (Fig. 3). Testicles are absent, Leydig's gland is relatively developed and spermiducts are convoluted ending in a rounded seminal vesicle. Lack of female structure allows to state that this present specimen does not displays a case of pseudo or true hemaphroditism (Atz, 1964), but rather a case of abnormality. All relevant case of clasper abnormalities are reported in some elasmobranch species in Table 2. It clearly appears that of the 16 cases herein presented, 12 are related to hermaphroditism, and only 4 cases could be considered as monstrosities (*sensu* Ribeiro-Prado *et al.*, 2008).

Tab. 2: Condition of clasper and pelvic fin (lack and/or atrophy) observed in some elasmobranch species recorded from different marine areas.
Tab. 2: Stanje klasperja in trebušne plavuti (odsotnost ali atrofija), ugotovljeno pri nekaterih vrstah hrustančnic iz različnih morskih predelov.

Species	Region	Condition of claspers and pelvic fins	Type of abnormality	Authors
Raja miraletus	Coast of Tunisia	Lack of left clasper	Hermaphroditism	Quignard & Capapé (1972)
Aetomylaeus nichofii	Coast of Pakistan	Atrophy of right clasper and pelvic fin	Hermaphroditism	Capapé & Desouter (1979)
Bathyraja interrupta	Coast of Alaska	Atrophy of both claspers	Hermaphroditism	Haas & Ebert (2008)
Pteroplatytrygon violacea	Coast of Brazil	Lack of left clasper	Hermaphroditism	Ribeiro-Prado *et al.* (2009)
Dasyatis tortonesei	Coast of Tunisia	Coast of Brazil	Hermaphroditism	Capapé *et al.* (2012)
Carcharhinus limbatus	Coast of Mexico	Atrophy of both claspers	Morphological abnormality	Hendon *et al.* (2013)
Urotrygon microphthalmum	Coast of Brazil	Atrophy of left clasper, lack of right clasper	Hermaphroditism	Santander-Neto & Lessa (2013)
Urotrygon chilensis	Coast of Mexico	Lack of left clasper	Hermaphroditism	Torres-Huerta *et al.* (2015)
Bathyraja parmifera	Bering Sea	?	Hermaphroditism	Mata (2015)
Zapteryx exasperata	Coast of Mexico	Lack of right clasper, atrophy of left pelvic fin	Hermaphroditism	González *et al.* (2016)
Myliobatis aquila	Coast of Tunisia	Atrophy of both claspers	Hermaphroditism	Rafrafi *et al.* (2017)
Pseudobathos percellens	Caribbean Sea	Lack of left clasper, atrophy of right pelvic fin	Hermaphroditism	Ehemann & González-González (2018)
Galeus melastomus	Coast of Algeria	Severe atrophy of right clasper and pelvic fin	Morphological abnormality	Capapé *et al.* (2019)
Potamotrygon marquesi	Coast of Brazil	Atrophy of both claspers	Morphological abnormality	da Silva & da Silva Casas (2020)
Zanobatos schoenleinii	Coast of Senegal	Lack of right clasper, atrophy of right pelvic fin	Hermaphroditism	Capapé *et al.* (2020a)
Zanobatos schoenleinii	Coast of Senegal	Lack of right clasper, atrophy of right pelvic fin	Morphological abnormality	This study

The causes of hermaphroditism in elasmobranchs species still remain unclear, and could be various and different. The causes of hermaphroditism in chondrichthyans remains difficult to explain (Atz, 1964), and they probably have an endogenous origin, genetic and/or hormonal as in other vertebrates. Unfavorable environmental conditions cannot be neglected such as radio-activity contamination (see Yano & Tanaka, 1989), though other polluants could also be involved. Additionally, hermaphrodite *A. longicephalus* from New Caledonia, including juveniles and adults, were collected with five other gonochoric species, showing that hermaphrodite specimens could live sympatrically with the gonochoric ones and reproduce (Iglesias *et al.*, 2005).

Among the causes of these reproductive abnormalities, lack or atrophy of claspers, Ehemann and Gonzàlez-Gonzàlez (2018) noted the most probable origin is related to the embryonic development. This opinion is in total accordance with Bensam (1965) and Moore (2015), who noted that such deformities are probably caused by intrauterine pressure exerted by other embryos in viviparous species. Conversely, Bonfil (1989) suggested that the pre-natal abnormalities have a genetic origin or related to mutations.

The lack of one clasper probably plays a minor role in reproduction processus due to the fact that male specimens introduce a single clasper during copulation (Chapman *et al.*, 2003). Conversely, atrophy of both claspers

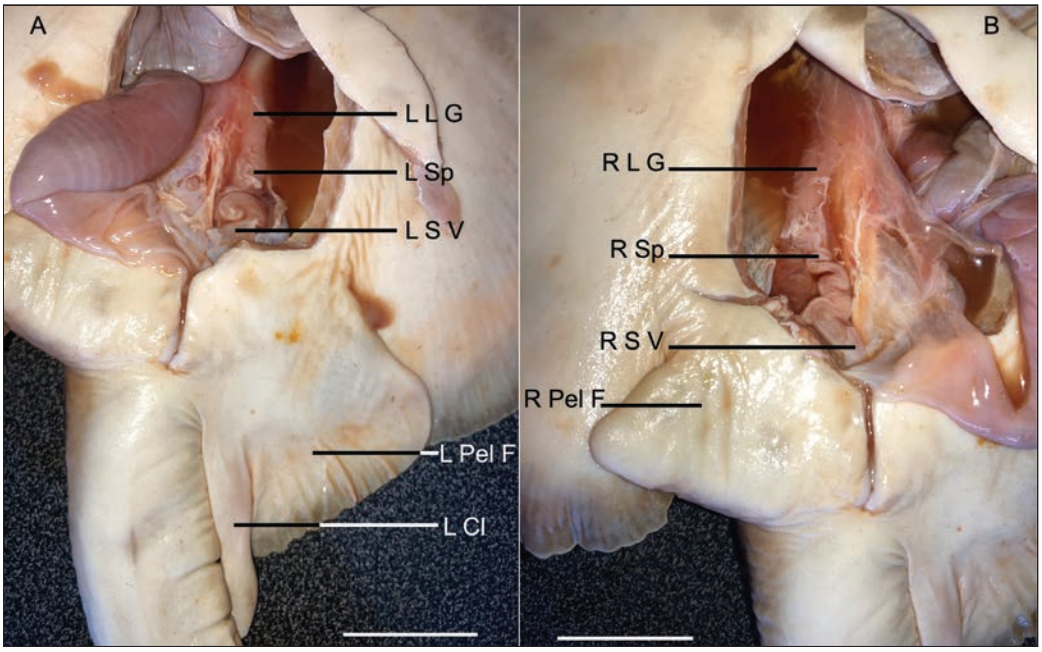


Fig. 3: Ventral view of the abdominal cavity of the abnormal specimen of** Zanobatus schoenleinii**. A. LLG: left Leydig's gland, LSp: left spermiduct, LSV: left seminal vesicle, LPelF: left pelvic fin, LCl: left clasper. B. RLG: right Leydig's gland, RSp: right spermiduct, RSV: right seminal vesicle, RPelF: right pelvic fin. Scale bar = 20 mm.

Sl. 3: Spodnja stran trebušne votline neobičajnega primerka vrste** Zanobatus schoenleinii**. A. LLG: leva Leydigova žleza, LSp: levi semenovod, LSV: leva semenska vrečka. LPelF: leva trebušna plavut, LCl: levi klasper. B. RLG: desna Leydigova žleza, RSp: desni semenovod, RSV: desna semenska vrečka. RPelF: desna trebušna plavut. Merilo = 20 mm.

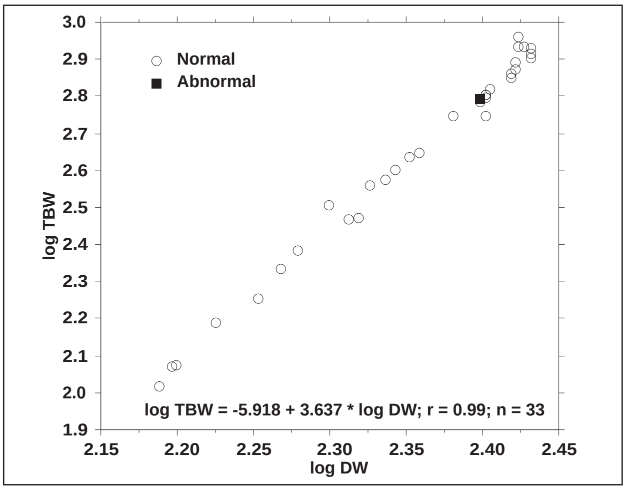


Fig. 4: Relationship total body mass (TBW) versus disc width (DW) expressed in logarithmic co-ordinates for abnormal and normal specimens of** Zanobatus schoenleinii **collected from the coast of Senegal.

Sl. 4: Odnos med celokupno telesno maso (TBW) in premerom diska (DW), pri neobičajnih in normalnih primerkih vrste** Zanobatus schoenleinii **iz senegalske obale, izražen v logaritemski skali.

reduces the success of the reproduction processus. The relationship TBW vs DW including the abnormal specimen and other specimens of similar sizes of *Z. schoenleinii* is log TWB = -5.918 + 3.637 * log DW; r = 0.99; n = 33, displaying a positive allometry (Fig. 4), all specimens having a regular increase in development. Therefore, lack of right clasper and reduced right pelvic fin did not assume the development of the abnormal specimen in the wild, similar patterns were provided in other batoid species (Capapé *et al.*, 2012, 2019).

Unfavourable environmental conditions probably play a role in different case of abnormalities reported in elasmobranch speecies such as large exposure to pollutants, especially in species having a benthic life (Ribeiro-Prado *et al.*, 2008; Diatta *et al.*, 2013). Such patterns were mostly reported in batoids which generally inhabit sandy-muddy bottoms (Ribeiro-Prado *et al.*, 2008). Diop *et al.* (2012) and Bonnin *et al.* (2016) noted that the coast of Senegal, especially around the touristic area of Dakar is facing to pollutants which is increasing in the wild since some decades and their impact on the local biodiversity cannot be totally ruled out. *Z. schoenleinii*, a benthic species remains probably the main instance due to the fact that several abnormal specimens were found in the area (Diatta *et al.,* 2013; Capapé *et al.*, 2020a,b; this study).

NAJDBA PRIMERKA VRSTE *ZANOBATUS SCHOENLEINII* (CHONDRICHTHYES: ZANOBATIDAE) LE Z ENIM KLASPERJEM IZ SENEGALSKE OBALE (VZHODNI TROPSKI ATLANTIK)

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POVZETEK

Avtorji poročajo o ulovu nenavadnega osebka skata vrste Zanobatus schoenleiniii *(Müller & Henle 1841) iz senegalske obale. Primerek je meril 250 mm v premeru diska (DW) in tehtal 621 g telesne teže (TBW). Bil je brez desnega klasperja, kar se je videlo že s hrbtne strani, in z nerazvito in pokrnelo trebušno plavutjo, še posebej na skrajnem robu. Seciranje trebušne votline je razkrilo samčev razmnoževalni aparat, ki je bil na obeh straneh podoben. Odsotnost samičjih delov kaže na dejstvo, da ne gre za primer pravega ali lažnega hermafroditizma, le morfološko anomalijo.*

Ključne besede: vrste skatov, odsotnost klasperja, morfološke anomalije, senegalska obala

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NEW EVIDENCE OF THE OCCURRENCE OF *KNOUTSODONTA PICTONI* (NUDIBRANCHIA, ONCHIDORIDIDAE) IN THE NORTHERN ADRIATIC

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ABSTRACT

The authors present new data on the recently described nudibranch Knoutsodonta pictoni *Furfaro & Trainito, 2017 in the Gulf of Trieste (northern Adriatic Sea). We hereby present the first record of this species in Slovenian territorial waters. A total of 22 specimens of* K. pictoni *were recorded by diving in the period from 2017 to 2021 at five localities in the Gulf of Trieste. All specimens were found in precoralligenous habitats in the depth range of 5 to 9 m, feeding on the encrusting bryozoan* Reptadeonella violacea *(Johnston, 1847). Numerous finds indicate that this only recently described and therefore little known nudibranch is much less rare than previously thought.*

Key words: *Knoutsodonta pictoni*, Gulf of Trieste, sea slug, precoralligenous, cryptic species

NUOVE PROVE DELLA PRESENZA DI *KNOUTSODONTA PICTONI* (NUDIBRANCHIA, ONCHIDORIDIDAE) NELL'ADRIATICO SETTENTRIONALE

SINTESI

Gli autori presentano nuovi dati su una specie di nudibranco descritta recentemente, Knoutsodonta pictoni *Furfaro & Trainito, 2017, nel Golfo di Trieste (Adriatico settentrionale). L'articolo fornisce il primo ritrovamento della specie nelle acque territoriali slovene. Un totale di 22 esemplari di* K. pictoni *sono stati trovati durante le immersioni effettuate nel periodo dal 2017 al 2021, in cinque località del Golfo di Trieste. Tutti gli esemplari sono stati rinvenuti in habitat precoralligeni, nell'intervallo di profondità da 5 a 9 m, mentre si nutrivano del briozoo incrostante* Reptadeonella violacea *(Johnston, 1847). I numerosi ritrovamenti indicano che questo nudibranco, descritto solo recentemente e quindi poco conosciuto, è molto meno raro di quanto si pensasse.*

Parole chiave: *Knoutsodonta pictoni*, Golfo di Trieste, lumaca di mare, precoralligeno, specie criptica

INTRODUCTION

Knoutsodonta pictoni Furfaro & Trainito, 2017 (Fig. 1) is a recently described nudibranch of the family Onchidorididae Gray, 1827. It is distributed in the western Mediterranean Sea in Spain (Ballesteros *et al.,* 2016; OPK Opistobranquis, 2020), in the Tyrrhenian and Ligurian Seas in Italy (Betti *et al*., 2017; Furfaro & Trainito, 2017), and in the northeast Atlantic Ocean in Ireland and Scotland (Hallas & Gosliner, 2015; Furfaro & Trainito, 2017 and references therein; nudibranch.org, 2021). The first record of the species in the Adriatic Sea was reported by Furfaro & Trainito (2017) in Sistiana, Gulf of Trieste. Morphological features characteristic of the species are: elliptical and dorsally flattened body with bristly appearance; base colour dark brown with blue and white speckles on the mantle; rhinophores white with 9 to 11 lamellae; gills dark brown with 9 to 10 bipinnate branchial leaves (Furfaro & Trainito, 2017).

The aim of this short note is to provide new data on the occurrence of this species in the Gulf of Trieste and on the ecology of this nudibranch, as well as reporting the first record of this species for the Slovenian coasts.

MATERIAL AND METHODS

Observations and sampling were carried out by scuba diving in the Italian and Slovenian parts of the Gulf of Trieste between 2017 and 2021, more specifically in Sistiana and Sistiana Castelreggio in the northern part of the Gulf of Trieste, in Barcola near the town of Trieste, and in the southern part of the gulf, Pirančekand Fiesa near the town of Portorož.

In Italy, the nudibranchs were observed from 2017 to 2020. Specimens were photographed with a Sea & Sea 2G camera with a Sea & Sea DS1 strobe using Nauticam CMC1 macro lens, and identified *in situ*. Depth and temperature were recorded at all sites.

In Slovenia, several bryozoan species were collected during a marine biodiversity survey in Natura 2000 sites in summer 2021. Depth and temperature were recorded. Nudibranchs and the bryozoan colonies on which they were found were identified in the laboratory and photographed under a stereomicroscope (Olympus SZX16) with a digital camera (Olympus DP25), with the nudibranchs subsequently deposited in the malacological collection.

Specimens were identified using the diagnostic features described by Furfaro & Trainito (2017). Systematics and validity of names were checked using the World Register of Marine Species [WoRMS].

RESULTS AND DISCUSSION

A total of 22 specimens (20 of which found in Italy and 2 in Slovenia) and 6 egg masses (found only in Italy) were photographed over a five-year period (from 2017 to 2021; see Tab. 1 for details). All specimens displayed the same colour pattern with little chromatic variability. In general, this species was found in winter and summer on precoralligenous rocky bottoms 5 to 9 m deep and in a temperature zone ranging from 7 to 26°C. The habitats where the specimens were observed were located under

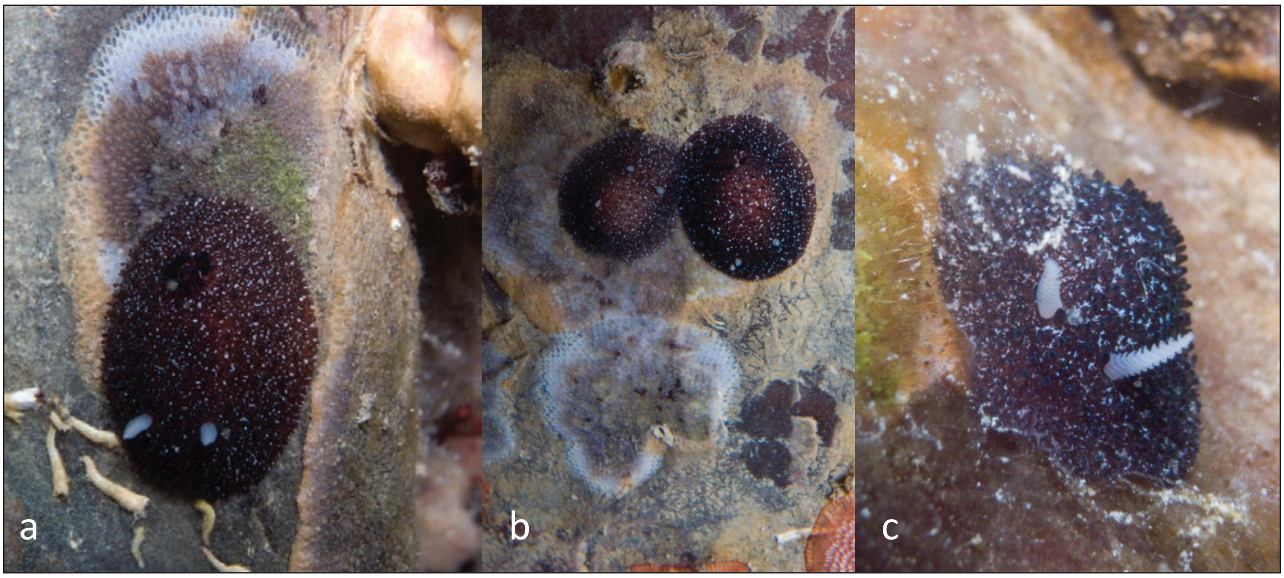


Fig. 1:** Knoutsodonta pictoni**; a – specimen feeding on the bryozoan** Reptadeonella violacea**, b – two specimens, and c – close-up of a specimen with visible white lamellate rhinophores (Photo: M. Fantin).

Sl. 1:** Knoutsodonta pictoni**; a – primerek se prehranjuje na mahovnjaku** Reptadeonella violacea**, b – dva primerka, in c – bližinski posnetek primerka z vidnima lamelastima rinoforjema (Foto: M. Fantin).

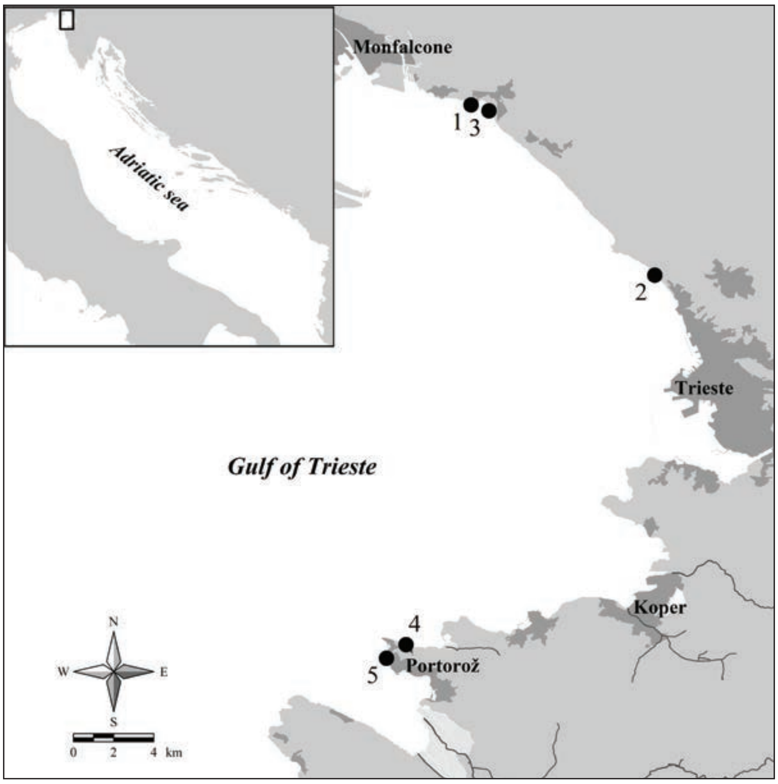


Fig. 2: Map of the Gulf of Trieste with five localities where the specimens of* Knoutsodonta pictoni *were found (black dots). The numbers next to the black dots represent the localities listed in Tab. 1.
Sl. 2: Zemljevid Tržaškega zaliva s petimi lokalitetami, kjer so bili najdeni primerki vrste* Knoutsodonta pictoni *(črni krogci). Številke poleg krogcev označujejo lokalitete, ki so navedene v Tab. 1.

Tab. 1: Data on the occurrence of* Knoutsodonta pictoni *in the Gulf of Trieste in the period 2017–2021.
Tab. 1: Podatki o pojavljanju vrste* Knoutsodonta pictoni *v Tržaškem zalivu v obdobju med 2017 in 2021.

date	locality number	locality	GPS N	GPS E	n	egg mass	depth (m)	T (°C)
14.1.2017	1	Sistiana	45°46′7.88″	13°37′21.19″	2	1	7	7
21.1.2017	2	Barcola	45°41′30.53″	13°44′20.26″	2	1	4	7
29.1.2017	1	Sistiana	45°46′7.88″	13°37′21.19″	2		8	8
30.1.2017	3	Sistiana Castelreggio	45°45′58.21″	13°38′2.04″	2		8	8
4.2.2017	3	Sistiana Castelreggio	45°45′58.21″	13°38′2.04″	2	1	9	9
5.2.2017	3	Sistiana Castelreggio	45°45′58.21″	13°38′2.04″	2		8	9
18.2.2017	1	Sistiana	45°46′7.88″	13°37′21.19″	2	1	9	9
10.2.2018	3	Sistiana Castelreggio	45°45′58.21″	13°38′2.04″	2	1	7	10
24.2.2018	3	Sistiana Castelreggio	45°45′58.21″	13°38′2.04″	2	1	8	10
10.3.2018	1	Sistiana	45°46′7.88″	13°37′21.19″	1		9	11
2.6.2020	1	Sistiana	45°46′7.88″	13°37′21.19″	1		8,5	16
20.7.2021	4	Fiesa	45°31′38.4″	13°34′42.54″	1		7	21
29.7.2021	5	Pirančak	45°31′16.75″	13°33′57.45″	1		5	26

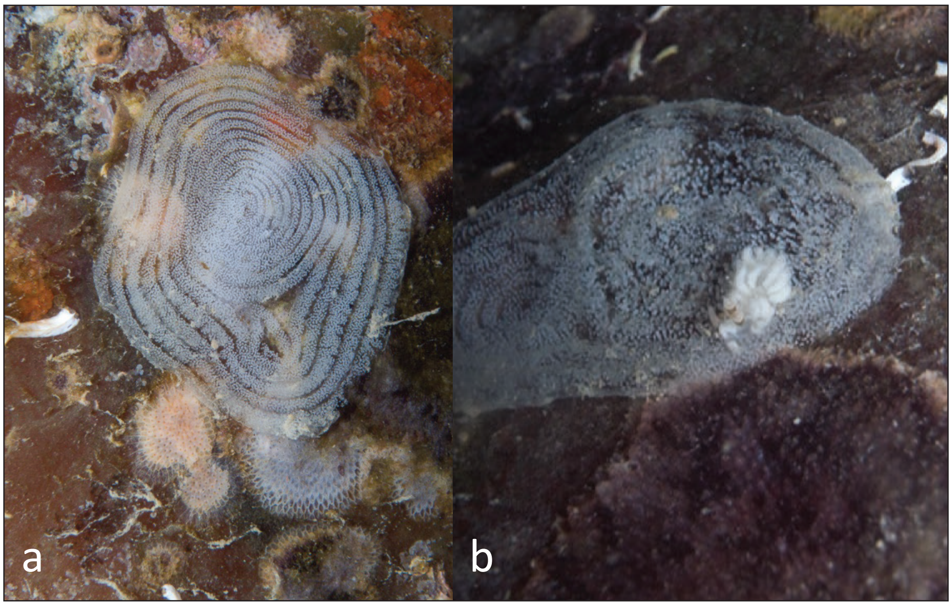


Fig. 3: Spawn of** Knoutsodonta pictoni**; a – white ribbon with eggs on the bryozoan** Reptadeonella violacea**, b – oviphagous nudibranch** Favorinus branchialis **feeding with the eggs of** K. pictoni **(Photo: M. Fantin).

Sl. 3: Mrest vrste** Knoutsodonta pictoni**; a – beli svitek z jajci na mahovnjaku vrste** Reptadeonella violacea**, b – ovifagni gološkrgar vrste** Favorinus branchialis **se hrani z jajci vrste** K. pictoni **(Foto: M. Fantin).

stones, on molluscan shells, and on rocks. In Sistiana the nudibranch was regularly observed in 2017, 2018, and 2020, in Sistiana Castelreggio it was recorded in the winters of 2017 and 2018, and in Barcola only once, in winter 2017. The spawning activities were observed from late January to May. The egg masses were white, concentrically folded and ribbon-shaped (Fig. 3a). On one occasion, an oviphagous nudibranch, *Favorinus branchialis* (Rathke, 1806), was photographed devouring an egg mass of *K. pictoni* (Fig. 3b). With regard to findings along the Slovenian coast, only two specimens were found in summer 2021, both small-sized (between 3 and 4 mm), probably juveniles.

The ecology of *K. pictoni,* being this nudibranch a recently described species, is poorly known. However, the numerous findings reported in this study indicate that it is far less rare than previously thought. All the specimens collected were found feeding on the encrusting cheilostomatid bryozoan *Reptadeonella violacea* (Johnston, 1847). The same was observed by Furfaro & Trainito (2017), suggesting a preferential predatory relationship. In fact, it is not uncommon for nudibranchs to feed on one prey species only (Todd & Havenhand, 1989). *R. violacea* is a common bryozoan species in the shallow waters of the Mediterranean Sea, living as an epiphyte in *Posidonia* meadows, on algae (Novosel, 2005), on the underside of stones, and on molluscan shells. Nudibranchs are mostly known as vividly coloured heterobranchs, while species with cryptic colouration are less well known. They use various camouflage strategies such as homochromy, countershading, and cryptic or disruptive colouration (Todd, 1981). These cryptic species, such as *K. pictoni*, were often overlooked in the past, due to their excellent camouflage. In fact, to date, only three species of the family Onchidorididae [*K. pictoni*; *K. neapolitana* (Delle Chiaje, 1841) and *K. depressa* (Alder & Hancock, 1842)] have been recorded in the Gulf of Trieste and throughout the northern Adriatic Sea (Ciriaco & Poloniato, 2016; Zenetos *et al*., 2016; Furfaro & Trainito, 2017; Lipej *et al*., 2018; present study). Therefore, continuous monitoring is necessary to extend our knowledge of these particular species, which often go unnoticed.

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NOVI PODATKI O POJAVLJANJU VRSTE *KNOUTSODONTA PICTONI* (NUDIBRANCHIA, ONCHIDORIDIDAE) V SEVERNEM JADRANU

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POVZETEK

Avtorji poročajo o novih najdbah pred kratkim opisanega polža gološkrgarja vrste Knoutsodonta pictoni *Furfaro & Trainito, 2017 v Tržaškem zalivu (severni Jadran). Navajajo prvi zapis o pojavljanju te vrste za slovenske vode. V obdobju med 2017 in 2021 je bilo na potapljaških vzorčenjih popisanih skupno 22 primerkov vrste* K. pictoni *na petih lokalitetah v Tržaškem zalivu. Vsi primerki so bili najdeni v prekoraligenu v globinskem pasu med 5 in 9 m, kjer so se prehranjevali s skorjastim mahovnjakom vrste* Reptadeonella violacea *(Johnston, 1847). Številne najdbe kažejo, da je ta pred kratkim opisana in slabo poznana vrsta pogostejša, kot so domnevali doslej.*

Ključne besede: *Knoutsodonta pictoni*, Tržaški zaliv, gološkrgarji, prekoraligen, kriptična vrsta

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BIODIVERSITY AND STRUCTURAL ORGANIZATION OF MOLLUSK COMMUNITIES IN THE MIDLITTORAL COASTAL AREA BETWEEN BOUZEDJAR AND ARZEW (WESTERN ALGERIA)

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ABSTRACT

The study presents an inventory and assessing the space-time organization of mollusk communities in the midlittoral coastal area between Bouzedjar and Arzew in western Algeria. A total of 32 species of Mollusca were identified at 5 sampling stations (systematic monthly sampling) during 2016/2017. Ecological indices such as the abundance of organisms (from 1167 to 2856 ind. m^{-2}), number of species (15 Gastropoda, 3 Bivalvia, and 1 Placophora), diversity (H'), Evenness (J'), applied to the data, indicate the coastal ecosystem is disturbed and unbalanced (particularly in Arzew) because of numerous human activities impacting this area. Thus, this study contributes to providing a distribution map and a database for the management, biomonitoring, and subsequent conservation of coastal ecosystems.

Key words: Benthic Mollusca, midlittoral, inventory, population dynamics, Algeria

BIODIVERSITÀ E ORGANIZZAZIONE STRUTTURALE DELLE COMUNITÀ DI MOLLUSCHI DEL PIANO MEDIOLITORALE NELLA ZONA TRA BOUZEDJAR E ARZEW (ALGERIA OCCIDENTALE)

SINTESI

Lo studio presenta un inventario e la valutazione dell'organizzazione spazio-temporale delle comunità di molluschi del piano mediolitorale nella zona costiera tra Bouzedjar e Arzew nell'Algeria occidentale. Un totale di 32 specie di Mollusca sono state identificate in 5 stazioni di campionamento (campionamento sistematico mensile) durante il periodo 2016/2017. Gli indici ecologici come l'abbondanza di organismi (da 1167 a 2856 ind. m^{-2}), il numero di specie (15 Gastropoda, 3 Bivalvia, e 1 Placophora), la diversità (H'), l'uniformità (J'), applicati ai dati, indicano che l'ecosistema costiero è disturbato e squilibrato (soprattutto in Arzew) a causa delle numerose attività umane che impattano questa zona. Questo studio pertanto contribuisce a fornire una mappa di distribuzione e un database per la gestione, il biomonitoraggio e la successiva conservazione degli ecosistemi costieri.

Parole chiave: molluschi bentonici, mediolitorale, inventario, dinamiche di popolazione, Algeria

INTRODUCTION

Marine mollusca play an important role in the structure and function of many coastal marine environments. Since their pelagic larval stages are associated with the life cycle of many species, they can rapidly disperse over large areas (Bourdages *et al.,* 2012). They are also considered to be an important part in the coastal food chain (Mastellar, 1987). Specific diversity largely depends upon coastal morphology (rocky, sandy, mixed shorelines), hydrodynamics (Guibout, 1987; Aminot *et al.,* 1994; Bouras *et al.,* 2007; Bouras, 2013), climate mechanisms, and nutrient levels (Redfield *et al.,* 1963; Belhadj, 2001). If abiotic factors constrain the distribution of the species, especially at large spatial scales (Pearson & Dawson, 2003), biotic interactions such as competition, predation, mutualism, facilitation, or parasitism are equally important in explaining their presence in habitat at different spatial scales (Boulangeat *et al.,* 2012; Kissling *et al.,* 2012; Wisz *et al.,* 2013).

The studied coastal zone is a particularly fragile and sensitive complex of habitats, subject to strong demographic and economic pressures (Kies & Taibi, 2011; Belhadj, 2001). To assess the different statuses of coastal communities, it is necessary to provide information on the biodiversity and functioning of ecosystems. This kind of information is required to establish biological importance of coastal zones and monitor the impact of disturbance factors (Adam *et al.*, 2015; Chabot *et al.,* 2007). A variety of biological indicators are used: at community level, the occurrence or absence of certain species, which is indicative of a variety of impacting factors; at ecosystem level, the structure of communities (species richness, abundance, biomass, structural indicators), biological processes (primary and secondary production, nutrient cycles) and food chain; structures and landscape heterogeneity, fragmentation or pollution can all be important environmental status indicators as well (Christine & Romain, 2010).

This study uses Mollusca data collected from the Algerian coast to provide an updated account of specific richness, distribution area, abundance, and biological diversity of mollusks in intertidal zones along the Oran coast for the purpose of assessing and monitoring the ecological status of this marine area. The aim is to provide a factual basis for supporting enhanced environmental action (effective and sustainable measures to be recommended for the conservation of endangered species in this region).

MATERIAL AND METHODS

The study area concerns the west Algerian coast, specifically the over 120 km long area along the meridional Mediterranean coast. Monitoring focused on five stations (Fig. 1). The sites were chosen from a selection of geographical locations representative of the entire coastline of Oran, notably taking the nearby ports (Bouzedjar and Arzew) and urban areas (La Madrague and Arzew) as centers of pollution sources and disturbance processes. These areas clearly contribute a variety of negative impacts associated with human activities, but the magnitude of spatial and temporal impacts on the coastal ecosystems is less clear. The principal characteristics of each sampled station are grouped in Table 1.

Monitoring and sampling

Systematic sampling at each station was carried out monthly during the period March 2016–February 2017. The adopted method for observing both biotic and abiotic parameters in the field involved sampling three 100 m long parallel linear transects (transects parallel to the coast) at each station.

A total of 5 quadrats of 1 m² in surface area marked at 20 m intervals along each of the three transect lines were used, resulting in a total of 15 quadrats for each monthly sampling. In order to carry out non-destructive sampling and respect the environment, large size Mollusca (limpets, mussels, and gastropods) were identified and counted on the spot while small size species were collected and stored in 5% formalin.

Mollusca species identification was based on the work by Bucquoy *et al.* (1887), Locard (1891), Norsieck (1982), Fisher *et al.* (1987), Riedl (1991), Lindner (2012), Hayward *et al.* (2014), and consulted for confirmation with the museum reference collection at the Scientific Institute of Rabat. The scientific names established follow the World Register Marine Species (WoRMS).

Ecological indices and data processing

Various indices were applied to assess the diversity characteristics of the Mollusca community in the space-time. Ecological indices were calculated according to the following formula:

- **Species richness index***:* ***S*** = *total number of species per site;*
- **Shannon diversity index***:* **H′** = $-\Sigma\, p_i \log_2 p_i$;
- **Evenness index***:* **J′** = $H' / Hmax = H' / \log_2 S$ *(it can be expressed as a percentage %)*

where: Hmax = maximum diversity or equifrequency; pi = (nj / N): relative frequency of species; nj: relative frequency of species j in the sampling unit; N: sum of specific relative frequencies (Shannon & Weaver, 1963).

The main diversity indices, with the Shannon-Wiener followed by the equitability index, are used to

Tab. 1: Principal characteristics of sampling stations.
Tab. 1: Glavne značilnosti vzorčevalnih postaj.

Stations	**Pollution**	**Remarks**
Bouzedjar Bay (S1)	The coastal environment is experiencing high levels of pollution: urbanization too close to the shore, discharges of domestic wastewater from the Bouzedjar agglomeration in the sea without prior treatment, as well as the wild degassing of fishing vessels and the discharge of defective packaging into adjacent coastal waters, contribute significantly to the deterioration of the beach and its bathing waters (Ghodbani, 2017).	Limited by two rocky advances: the headland of Jebel Moul-el-Bhar in the east and Cape Figalo in the west. The bay opens to a depth of about 700 m and a length of 2 km. Presence of tar concretion on rocks and sand, because of its proximity to ports.
Madagh (S2)	(Non-impacted area) being relatively distant from urban and industrial anthropogenic pressures (Kherraz, 2004; Allal, 2007; Benali, 2009)	Considered as reference station
La madrague (S3)	Close to centre of human activities (PDAU, 1995).	Urban areas with high perturbance by fishermen
Kristel (S4)	High attendance by fishermen and national tourists during the spring and summer period.	Considered as reference station
Gulf of Arzew (S5)	Close to centre of human activities (PDAU, 1995).	Presence of tar concretion on rocks and sand, because of its proximity to ports.

quantify both the taxonomic richness and the distributions of the community's taxa. These indices have also been used to make a comparison among the communities of the different stations and to study temporal changes in diversity related to pollution reduction (Pearson & Rosenberg, 1978). These main indices of equitability most often consist in establishing the relationship between the measured diversity and the maximum theoretical diversity for a given sample size and number of species (Grall & Coïc, 2006).

The Shannon index (H'), derived from information theory, is considered as a heterogeneity index of diversity and is more sensitive to rare species than Simpson's index. H' usually varies between 1 and 4.5 bits. The Shannon-Wiener index tends to 0 (minimum) when all individuals in a population belong to a single species (low values indicating the preponderant species), and to 1 (maximum) when all individuals are equally distributed over all species (Grall & Coïc, 2006). According to Picard & Courtial (2015), the Piélou evenness index (J') measures the distribution of individuals within species, regardless of species richness. The value of Piélou equitability index varies from 0 (single species dominance) to 1 (equidistribution of individuals over all species). The more this index J' tends to 1, the more the population is scarcely contrasted (the species is distributed in an equiprobable sample), the more it tends to 0, the more this stand is contrasted (a very varied quantitative representation of the species in the sample). For example, a value of J' = 0.40 will mean that randomly selected individuals have only a 40% probability of being different and a 60% chance of being of the same species, therefore the population is not very diversified. Consequently, a high value of H' can only be interpreted as stand disturbance if it is accompanied by the evenness index (J'). In fact, it is necessary to take both values into account concomitantly in order to accurately assess the state of an environment, while assigning thresholds to the value of H' alone is relatively inappropriate (Grall & Coïc, 2006);

- PCA:

Principal component analysis (PCA) consists in finding the best simultaneous representation of two sets constituting the rows and columns of a contingency table: observation points (stations) and variable points (species). The distributions are expressed in percentages so that the distances make sense. The data in the matrix can undergo a Log or double square root transformation in order to stabilize the variances by giving importance to rare species. The distance used is that of Chi-square. The graphs used represent a simultaneous projection of column points (stations) and line points (species) in a space having as many dimensions as there are measured variables (Ménesguen, 1980).

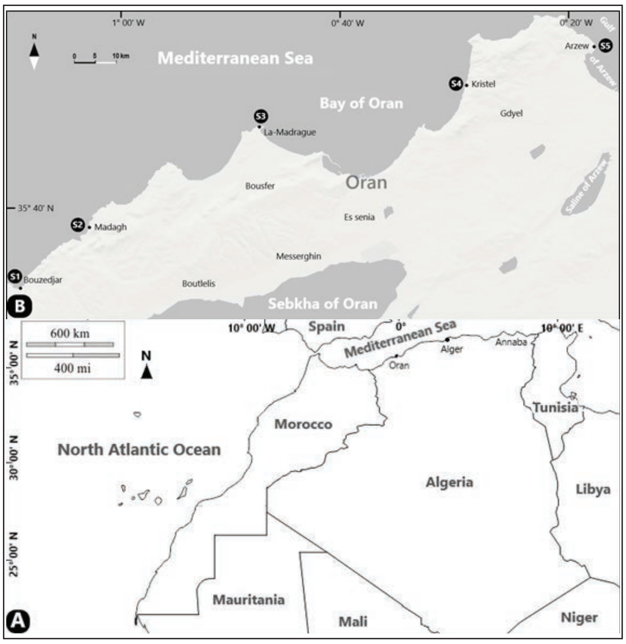


Fig. 1: Location of study sites. A. Location of Oran on the North African coast; B. Oran coast; Sampling stations: S1 (Bouzedjar), S2 (Madagh), S3 (La Madrague), S4 (Kristel), and S5 (Arzew).
Sl. 1: Zemljevid obravnavanega območja. A. Oran na severnoafriški obali; B. oranska obala; Vzorčevalne postaje: S1 (Bouzedjar), S2 (Madagh), S3 (La Madrague), S4 (Kristel), in S5 (Arzew).

In general, we use a representation of the planes formed by two orthogonal axes, with the latter representing a maximum of variance for the analysis (most of the time, the first two or three axes are used). The results are interpreted in terms of proximity between stations, between species, or between stations and species. The relative or absolute contributions of each station or species on each axis provide essential elements for interpretation, while their squares of cosine reflect a greater or lesser representativeness of the axis for the variable considered.

Hierarchical ascendant classification (HAC) consists of grouping the closest species in the form of a dendrogram, whose length of branches represents the average or total distance between the species and groups of species, *i.e.*, their percentage of similarity. The hierarchical classification is particularly interesting in analyzing differences in community structure along enrichment gradients in organic matter. Easy to calculate and interpret, it has allowed for the development of several theories concerning the spatial and/or temporal evolution of the benthic fauna following pollution. While dendrograms are simple to use, they have four disadvantages (Field *et al.*, 1982):

- The hierarchy is irreversible: once a sample has been placed in a group, it loses its identity;
- Dendrograms only show intergroup relations. The level of similarity indicated is that of the average of the intergroup values;
- The sequence of the samples in a dendrogram is arbitrary, and two adjacent samples belonging to different groups are not necessarily the most similar;
- Dendrograms emphasize discontinuities and force continuous series to be organized into discrete classes.

Data analyses

The quantitative data table was processed using R software (version: 3.4.3, year: 2017), univariate: abundance (A), number of species (S), Shannon diversity (H′) and evenness (J′), and multivariate: PCA and HAC.

To establish a comparison of the different indices of ecological diversity, ANOVA analysis was chosen. ANOVA (analysis of variance) is a statistical test well suited for comparisons of means for sample numbers > 30 (Underwood, 1997). Prior to applying ANOVA, tests of normality and homogeneity of variances were checked using the Bartlett and Levene tests, respectively. Whenever the homogeneity of variances was significant (a significant difference for a protection factor of 0.5%), the one-factor ANOVA test was performed.

To estimate the influence of environment characteristics (Oran's coastline) on Mollusca benthic species and to visualize multidimensional data in graphics, a table of taxonomic abundances was compiled using Principal Component Analysis (PCA) and Ascending Hierarchical Classification (HAC).

RESULTS

Assessment of coastal water and sediment quality to determine human activity impact on the marine environment involves measurement of physicochemical and eco-toxicological parameters. However, since these parameters may vary naturally between different habitats, they only have descriptive value, portraying an ecosystem at a particular time, which can make it difficult to deduce the impacts of anthropogenic activities on benthic communities. Hence, biological criteria need to be considered in order to evaluate ecosystem statues (Dauer, 1993). Compiling baseline biological information usually begins with diversity.

A total of 32 species of mollusks were identified at the 5 monitored stations; the species and the related Mollusca families are indicated in Table 2 as follows:

Tab. 2: Mean density (ind. m^{-2}) of species at 5 stations of Oran littoral, between March 2016 and February 2017.
Tab. 2: Srednja gostota (os. m^{-2}) vrst na 5 postajah na oranski obali med marcem 2026 in februarjem 2017.

Family	Species	Codes	S1	S2	S3	S4	S5
Aplysidae	*Aplysia punctata* (Cuvier, 1803)	e 20			<1		
Calliostomatidae	*Calliostoma ziziphinum* (Linnaeus, 1758)	e 21	<1	<1		<1	<1
Carditidae	*Cardita calyculata* (Linnaeus, 1758)	e 25			<1	1-10	<1
Cerithiidae	*Cerithium lividulum* (Risso, 1826)	e 18			<1		11-50
	Bittium reticulatum (Da Costa, 17778)	e 22		<1	<1	<1	<1
Chitonidae	*Chiton olivaceus* (Sopengler, 1797)	e 3	1-10	1-10	11-50	11-50	1-10
Columbellidae	*Columbella rustica* (Linnaeus, 1758)	e 15	<1	<1		<1	<1
Conidae	*Conus ventricosus* (Gmelin, 1791)	e 17		<1	<1		<1
Costellariidae	*Pusia ebenus* (Lamark, 1819)	e 29		<1			
	Pusia tricolor (Gmelin, 1791)	e 30					<1
Epithoniidae	*Gyroscalla lamellosa* (Lamark, 1822)	e 27		<1			
Fissurellidae	*Fissurella nubecula* (Linnaeus, 1758)	e 9	<1	<1	1-10	<1	<1
Littorinidae	*Melarhaphe neritoides* (Linnaeus, 1758)	e 1	51-300	301-1000	>1000	301-1000	>1000
	Echinolittorina punctata (Gmelin, 1791)	e 2	51-300	301-1000	51-300	>1000	1-10
Muricidae	*Stramonita heamastoma* (Linnaeus, 1758)	e 19	<1	<1	<1	<1	
	Hexaplex trunculus (Linnaeus, 1758)	e 31				<1	
Mytilidae	*Mytilus galloprovincialis* (Lamark, 1819)	e 23	1-10	11-50	51-300	51-300	1-10
Patellidae	*Patella caerulea* (Linnaeus, 1758)	e 5	1-10	11-50	1-10	1-10	1-10
	Patella ulyssiponensis (Gmelin, 1791)	e 6	1-10	11-50	1-10	1-10	1-10
	Patella ferruginea (Gmelin, 1791)	e 7	1-10	1-10	1-10	1-10	<1
	Patella rustica (Linnaeus, 1758)	e 8	1-10	1-10	11-50	1-10	<1
	Cymbula safiana (Lamark, 1819)	e 10	<1				
Pisaniidae	*Pisania striata* (Gmelin, 1791)	e 16		<1		<1	<1
	Aplus dorbignyi (Payraudeau, 1826)	e 26				<1	<1
Rissoidae	*Alvania cimex* (Linnaeus, 1758)	e 28					<1
	Peringiella denticulata	e 32				<1	<1
Siphonariidae	*Siphonaria pectinata* (Linnaeus, 1758)	e 4	11-50	1-10	11-50	11-50	11-50
Trochidae	*Phorcus turbinatus* (Born, 1778)	e 11	1-10	11-50	11-50	1-10	1-10
	Phorcus articulatus (Lamark, 1822)	e 12		<1	1-10		11-50
	Phorcus richardi (Payraudeau, 1826)	e 14		1-10	<1		<1
	Steromphala rurilineata (Michaud, 1829)	e 13		<1	<1	1-10	<1
Veneridae	*Calista chione* (Linnaeus, 1758)	e 24		<1	<1	<1	<1

Codes: Species number; Stations: S1 (Bouzedjar); S2 (Madagh); S3 (La Madrague); S4: (Kristel); S5 (Arzew); gaps: indicate the species was absent • <1 ; ● 1-10 ; ● 11-50 ; ● 51-300 ; ● 301-1000 ; ● >1000 ind m-2

- **Gastropoda (15)**: Aplysiidae, Calliostomatidae, Cerithiidae, Columbellidae, Conidae, Costellariidae, Epitoniidae, Fissurellidae, Littorinidae, Muricidae, Patellidae, Pisaniidae, Rissoidae, Siphonariidae, Trochidae;
- **Bivalvia (3)**: Mytilidae, Carditidae, Veneridae;
- **Polyplacophora** (1): Chitonidae.

Twelve species were common along all the studied littoral transects: *Melarhaphe neritoides, Echinolittorina punctata, Chiton olivaceus, Siphonaria pectinata, Pattela caerulea, P. ulyssiponensis, P. ferruginea, P. rustica, Fissurella nubecula, Phorcus turbinatus, Stramonita haemastoma,* and *Mytilus galloprovincialis.*

Thirteen species less common species only occurred at some of the stations: *Phorcus articulatus, Steromphala rarilineata, Phorcus richardi, Columbella rustica, Pisania striata, Conus ventricosus, Cerithium lividulum, Calliostoma zizyphinum, Bittium reticulatum, Callista chione, Cardita calyculata, Aplus dorbignyi,* and *Peringiella denticulata.*

Seven species were present at one station only: *Cymbula safiana, Pusia ebenus, Gyroscala lamellosa, Aplysia punctata, Hexaplex trunculus, Pusia tricolor,* and *Alvania cimex.*

Mollusca assemblages

The relative abundances of different taxonomic groups (Fig. 2) highlight the similarities and differences in specific composition between the studied sites. These are commented upon as follows:

Bouzedjar (S1) displayed a low global number of species (S = 15). *Melarhaphe neritoides* was abundant (54%), followed by *Echinolittorina punctata* (30%). (*M. neritoides* and *E. punctata* were common and abundant all along the studied coast [84%]). *Mytilus galloprovincialis* (6%) ranked 3rd but with a very low frequency of occurrence (*f* = 3%). *Siphonaria*

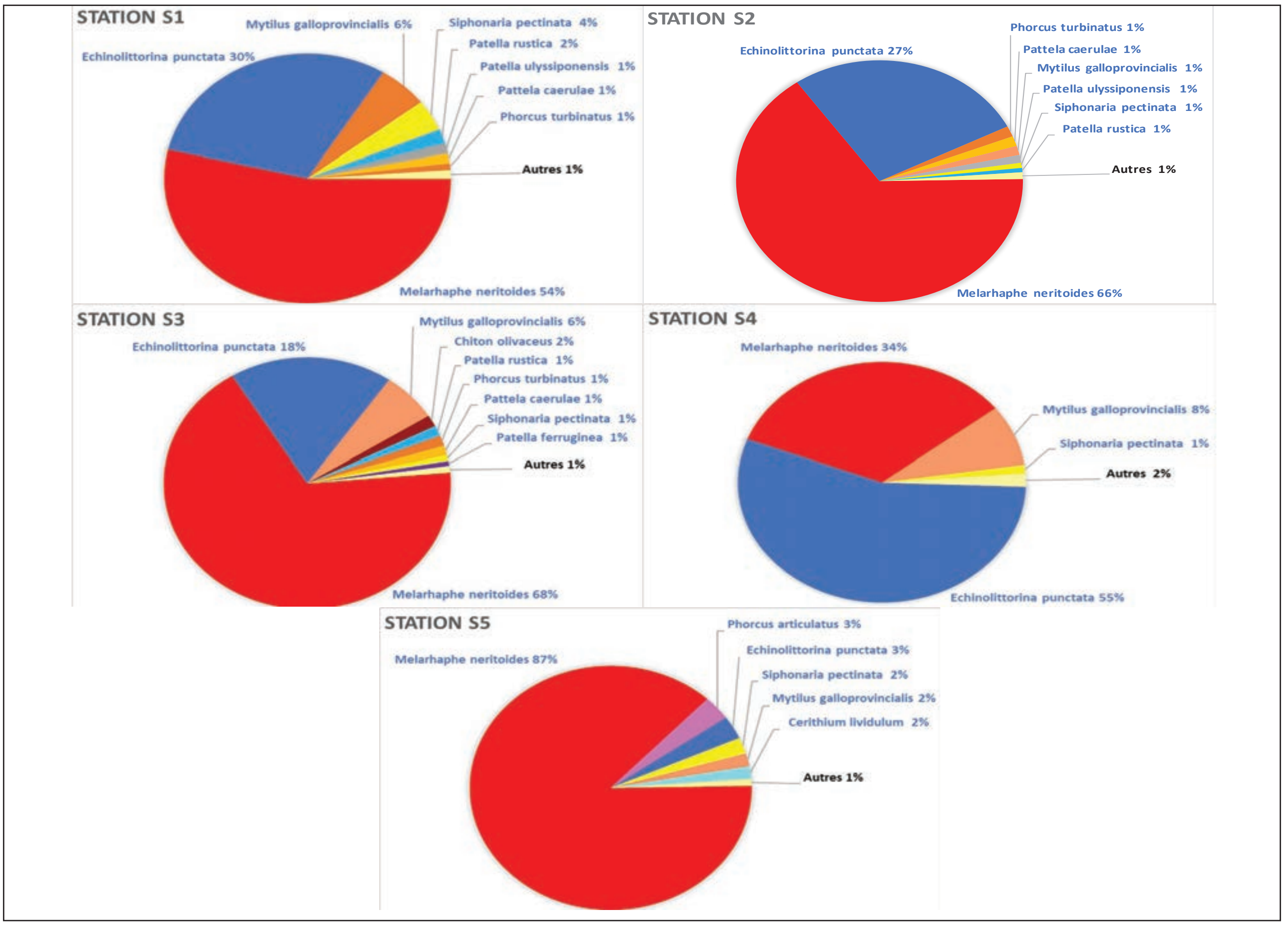


Fig. 2: Spatial distribution (%) of Mollusca species in the midlittoral zone of Oran between March 2016 and February 2017.
Sl. 2: Prostorska razširjenost (%) mehkužcev v bibavičnem pasu pri Oranu med marcem 2016 in februarjem 2017.

Tab. 3: Results from the ANOVA analysis on the spatial variation of Mollusca general descriptors (total density, number of species, Shannon-Wiener diversity index and Pielou's evenness [J'] of density of all Mollusca taxa) between March 2016 and February 2017.
Tab. 3: Rezultati prostorske variabilnosti glavnih deskriptorjev (celotna gostota, število vrst, Shannon-Wiennerjev diverzitetni indeks in Pieloujev indeks enakomernosti porazdelitve [J']) na podlagi analize ANOVA.

Sources	Df	Sum Sq	Mean Sq	F	Pr(>F)
Total density					
Stations	4	36700948	9175237	30.76	1.87e-13 ***
Residuals	55	16406493	298300		
Significant values	S1(a); S2(b); S3(b); S4(c); S5(b)				
Number of species (S)					
Stations	4	249.9	62.47	13.87	0.0000000696 ***
Residuals	55	247.8	4.51		
Significant values	S1(a); S2(a); S3(a); S4(a); S5(b)				
Diversity (H')					
Stations	4	3.834	0.9586	9.675	0.00000536 ***
Residuals	55	5.450	0.0991		
Significant values	S1(b); S2(b); S3(b); S4(b); S5(a);				
Evenness (J')					
Stations	4	0.3817	.09543	15.13	0.0000000211 ***
Residuals	55	0.3468	0.00631		
Significant values	S1(c); S2(bc); S3(b); S4(b); S5(a);				

- Significant codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
- significant values have different letter (a, b, c); Df: degrees of freedom, Sum Sq: summer square, Mean Sq: mean square; F statistic; Pr(<F): probability level; S1, S2, S3, S4, S5: Stations.

pectinata was also observed in high abundance (4%) at S1 and in a similar abundance at S5 (2%). The species present at S1 were: *Patella rustica* (2%), then *P. ulyssiponensis, P. caerulea, Phorcus turbinatus, Stramonita haemastoma* and *Mytilus galloprovincialis* (≈1% each species). The remaining species, each representing less than 1% of the total Mollusca biodiversity, were (in descending order): *Patella ferruginea, Chiton olivaceus, Fissurella nubecula, Cymbula safiana, Stramonita haemastoma, Columbella rustica, Calliostoma zizyphinum*.

At Madagh (S2) global species richness was high: 23 species. The most abundant in this Mollusca community were Littorina species (93%). Also abundant were *Melarhaphe neritoides* (66%), followed by *Echinolittorina punctata* (27%). *Phorcus turbinatus, Pattela caerulea, Mytilus galloprovincialis, Patella ulyssiponensis, Pattela rustica* and *Siphonaria pectinata* were occasionally observed (Tab. 1, Fig. 2). The remaining species, representing only 1% of the totality, appeared in the following descending order: *Patella ferruginea, Chiton olivaceus, Steromphala rarilineata, Fissurella nubecula, Phorcus articulatus, P. richardi, Stramonita haemastoma, Columbella rustica, Pisania striata, Callista chione, Conus ventricosus, Calliostoma zizyphinum, Gyroscala lamellosa, Pusia ebenus, Bittium reticulatum, Cymbula safiana*.

La Madrague (S3) revealed 21 species. Overall, the Littorines predominated (86%): *more specifically, Melarhaphe neritoides* (68%), followed by *Echinolittorina punctata* (18%), and *Mytilus galloprovincialis* (6%). Unlike in other sites, *Chiton olivaceus* (2%) was more abundant at this station. The species *Patella rustica, Phorcus turbinatus, Pattela caerulea, Siphonaria pectinata* and *Patella ferruginea* all shared the 5th position. The remaining species, representing only 1% of all Mollusca, occurred in the following descending order: *Patella ulyssiponensis, Phorcus articulatus, Fissurella nubecula, Stramonita*

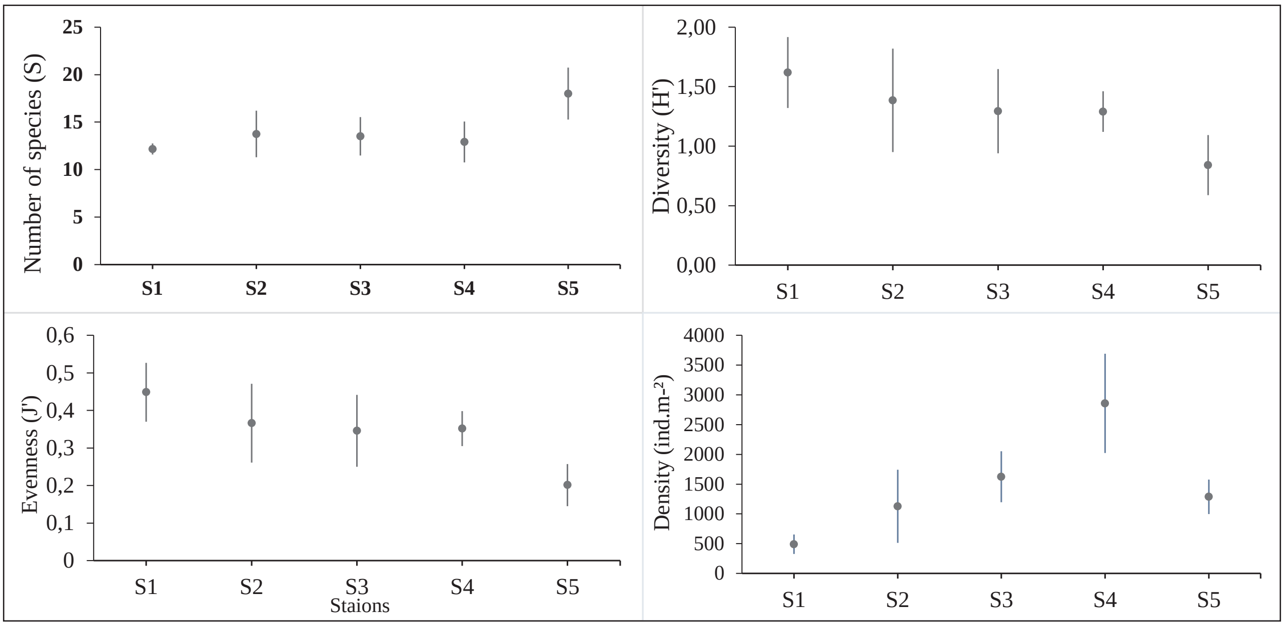


Fig. 3: Mean ±SE values of Mollusca general descriptors at each station between March 2016 and February 2017. Descriptors include total Mollusca density (number ind.m^{-2}) and number of species, the Shannon-Wiener diversity index (H'), and Pielou's evenness (J') per sample.
Sl. 3: Srednje ±SE vrednosti glavnih deskriptorjev mehkužcev na vsaki postaji med marcem 2016 in februarjem 2017. Deskriptorji vključujejo celotno gostoto mehkužcev (število osebkov na m^{-2}), število vrst, Shannon-Wiennerjev diverzitetni indeks (H'), in Pieloujev indeks enakomernosti porazdelitve (J') na posamezen vzorec.

haemastoma, Cerithium lividulum, Phorcus richardi, Aplysia punctata, Bittium reticulatum, Steromphala rarilineata, Conus ventricosus, Callista chione, Cardita calyculata.

At Kristel (S4), the global species richness was estimated at 22. The periwinkles with 89% were well represented and were the most abundant at this station. *Echinolittorina punctata* (55%) was most abundant, followed by *Melarhaphe neritoides* (34%). As in S3, *Mytilus galloprovincialis* (a little more abundant east of the Oran littoral) was the most common non- periwinkle, followed by *Siphonaria pectinata* (1%). The remaining species (2% of all Mollusca) were found in the following descending order: *Chiton olivaceus, Pattela caerulae, Phorcus turbinatus, Patella ulyssiponensis, Patella rustica, Patella ferruginea, Phorcus richardi, Stramonita haemastoma, Bittium reticulatum, Fissurella nubecula, Cardita calyculata, Pisania striata, Columbella rustica, Calliostoma zizyphinum, Callista chione, Hexaplex trunculus, Aplus dorbignyi, Peringiella denticulata*.

Arzew (S5) displayed the highest global species richness (27 species). *Melarhaphe neritoides* ranked 1st with 87%, which was the highest on the entire Oran coastline. The order afterwards changed enormously compared to other sites. For the first time *Echinolittorina punctata* occupied 3rd place, after *Phorcus articulatus* (3%) which took 2nd place. *Siphonaria pectinata, Mytilus galloprovincialis,* and *Cerithium lividulum* were similarly common at 2%. Other notable species (< 2%) were *Chiton olivaceus, Phorcus turbinatus, Patella ulyssiponensis, Patella caerulea, Bittium reticulatum, Peringiella denticulata, Patella ferruginea, Columbella rustica, Patella rustica, Calliostoma zizyphinum, Pisania striata, Phorcus richardi, Stramonita haemastoma, Fissurella nubecula, Aplus dorbignyi, Cardita calyculata, Conus ventricosus, Steromphala rarilineata, Pusia tricolor, Alvania cimex,* and *Callista chione*.

Spatial and temporal variation of general descriptors

The various diversity indices currently used make it possible to study the structure of stands with or without reference to a concrete space-time framework. They make it possible to do a quick assessment of stand biodiversity, corresponding to a single digit. The calculation of ecological indicators at the various stations allows the presence of dominant species to be identified. However, their synthetic nature can prove to be a handicap since it masks a large part of the information.

Spatial variability

Mollusca species diversity among the sampling stations, as revealed by diversity indices, is presented in Fig. 3.

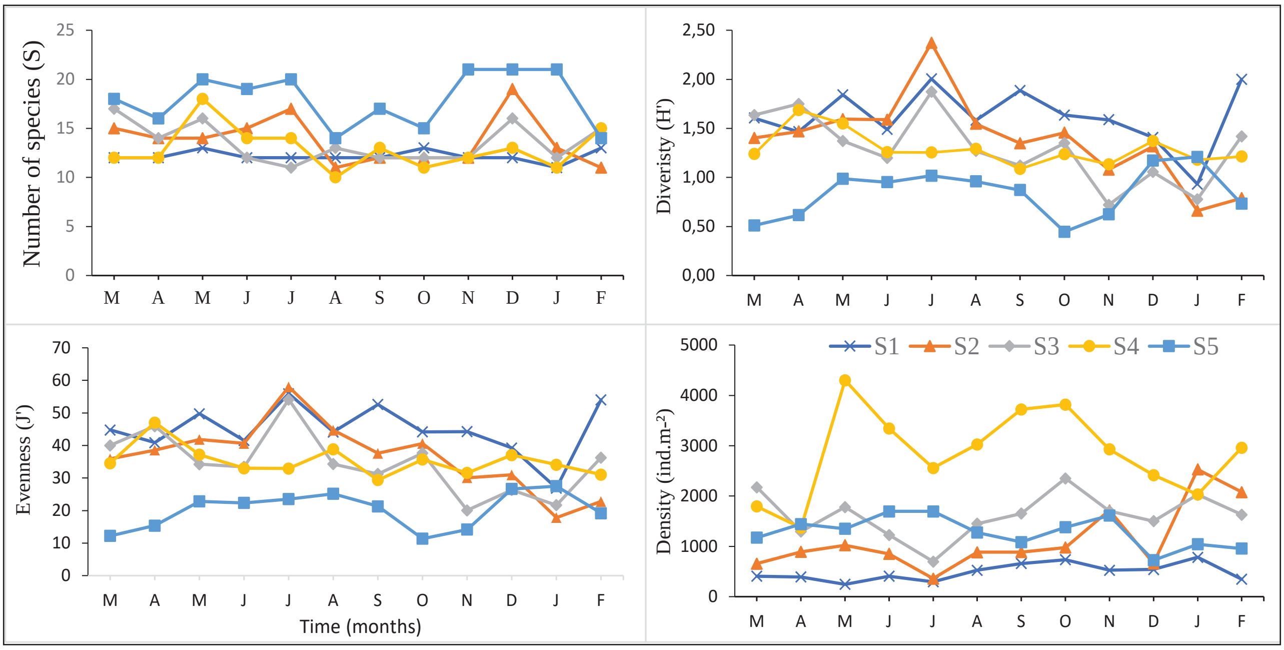


Fig. 4: Temporal variation of general descriptors (density, number of species, Shannon-Wiener diversity index and Pielou's evenness) between March 2016 and February 2017.
Sl. 4: Časovne spremembe glavnih deskriptorjev (gostota, število vrst, Shannon-Wienerjev diverzitetni indeks ter Pieloujev indeks enakomernosti porazdelitve) med marcem 2016 in februarjem 2017.

Total density

Regarding the total density of Mollusca, this study was able to demonstrate that the community of Mollusca is heterogeneous on a spatial scale. On the one hand, stations S2 (1127 ind.m^{-2})^{b}, S3 (1624 ind.m^{-2})^{b} and S5 (1287 ind.m^{-2})^{b} proved statistically identical ($p > 0.05$). On the other hand, the ANOVA1 test (Fig. 3, Tab. 3) assigned to stations S2, S3, and S5 the same letter of significance (b), which shows that the density is statistically similar ($p > 0.05$). Still according to the ANOVA1 test, these 3 stations were very significantly different ($p < 0.001$) from S1 (489 ind.m^{-2})^{a} and S4 (2856 ind.m^{-2})^{c}. The highest heterogeneity was observed at S4, the lowest at S1. This suggests that whereas stations S2, S3, and S5 recorded more homogeneous communities of Mollusca, the latter formed very heterogeneous communities at stations S1 and S4, in terms of density. Our data have also shown an average annual density (< 1 ind.m^{-2}) and a reduced annual frequency of occurrence (f < 10%) for several taxa across the entire Oran coast.

Number of species

With regard to the number of species (S), we have noticed that there are two considerably different groups of stations. The average number of species differs significantly ($p < 0.001$) between station S5 (18)^{b} and the group of stations S1 (12)^{a}, S2 (14)^{a}, S3 (14)^{a}, and S4 (13)^{a} (Tab. 3, Fig. 3).

Diversity H'

The diversity index (H') of Molluscan species follows the same pattern as that of the number of species (Fig. 2). Based on Table 3, we can see that the diversity at station S5 (0.84)^{a} is significantly lower ($p < 0.001$) compared to the group of stations S1 (1.62)^{b}, S2 (1.38)^{b}, S3 (1.29)^{b}, and S4 (1.29)^{b}.

Evenness J'

Regarding evenness (J'), the results obtained from ANOVA1 test differ from other variables. ANOVA1 test (Tab. 3) assigned stations S2, S3, and S4 the same letter (b) of significance. That means that the index (J') was statistically similar ($p > 0.05$). The index (J') of station S2 (36.62)^{bc} was not significantly different from that of station S1 (44.85)^{c}; in contrast, it was very significantly different ($p < 0.001$) from S5 (0.20)^{a}. Index (J') in stations S3 (0.35)^{b} and S4 (0.35)^{b} was significantly different from that of S1 (0.45)^{c} and S5 (0.20)^{a}. Station S1 had the highest index (J'), the lowest index was encountered at station S5 (Fig. 3).

Temporal variability

The monthly results of the ecological indices of Mollusca are shown in Fig. 4.

Total density

The results show that the total density at station S4 decreases below 2000 ind.m^{-2} only in March and April, while exceeding 4000 ind.m^{-2} in May. Stations S3 and S5 have a total density comprised between 1000 and 2000 ind.m^{-2} almost year round. At station S3, the density exceeds 2000 ind.m^{-2} in March, October, and January, while at station S5 it exceeds 1500 ind.m^{-2} in June, July, and November. A density of less than 1000 ind.m^{-2} was recorded in July at station S3, as well as in December and February at S5. Station S2 has a total density of 500 to 1000 ind.m^{-2} almost year round. The density drops below 1500 ind.m^{-2} in November, January, and February, dropping below 500 ind.m^{-2} only in July. Unlike other stations, the total density at S1 is usually between 300 and 800 ind.m^{-2}, dropping below 300 ind.m^{-2} in May only.

Number of species

For stations S1 to S4 we note that the annual average number of species varies between 12 and 14. At station S1, more than 13 species have never been found (February, May, October). At S2, the number of species reached 17 and 19 in July and December, respectively. At S3, the number of species was 16 in May and December, increasing to 17 in March. The number of species at S4 decreased from 18 species in May to only 10 species in August. Exceptionally, at station S5, the annual average number of species was 18. The species richness exceeded 18 species during two three-month periods: from March to June, and between November and January. The species richness never dropped below 14 species throughout the year.

Diversity H′

From S1 to S4, the diversity (H′) recorded during most months was greater than 1. At S5, the diversity was H′ ≤ 1 most of the time, except in December and January, when H′ was 1.17 and 1.21, respectively. At S1 the diversity decreased in January to a minimum of 0.93, while a maximum of 2 was reached in July. At station S2, the diversity was 0.66 and 0.79 in January and February, respectively, while in July it reached a maximum of 2.37. At station S3, diversity fell below the value of 1 only during November and January, to 0.72 and 0.78, respectively. Unlike other stations, the value of H′ at S4 remained between 1 < H′ < 2 throughout the year.

Evenness J′

Most of the year, equitability (J′) ranged from 0.20 to 0. The weakest evenness was recorded at 0.11 in October at station S5, the highest at 0.58 in July at station S2. At station S1, the index remained ≥ 0.40 throughout the year, with the exception of January when it equaled 0.27. At S2, evenness reached its maximum in July with a value of 0.58, while its minimum, 0.18, was recorded in January. At S3, J′ reached the highest value of 0.54, also in July, and the lowest 0.22 in November. At station S4, evenness was above 0.30 for most of the year. In September, J′ reached its lowest value of 0.29, while its highest value equaled 0.47 in April. Unlike station S2, evenness at S5 remained below 0.30 throughout the year. The highest value (J′ = 0.27) was recorded in December and January, the lowest (J′ = 0.11) in October.

Multivariate analysis

Multivariate analysis makes it possible to summarize the data correlation structure described by several quantitative variables, by identifying the underlying factors common to the variables (complementary qualitative variables), and is able to explain a large part of the variability of data.

The total information given in Fig. 5 on axes 1 and 2 is 28.79% (axis 1: 18.24% and axis 2: 10.55%). In the correlation circle, the species are divided into 4 large groups, two of them are distributed with respect to axis 1, the third is positioned on axis 2, and the fourth is diagonal.

The opposing groups are negatively correlated with each other:

the first group of species is positioned on axis 1 in a positive way and is well correlated with north coast exposure (Expos. N), central location on the coast (L. C), and the tender nature of the rock (RT). These species are: *Fissurella nubecula (e11), Patella ulyssiponensis (e7), Patella ferruginea (e8), Patella caerulea (e6), Patella rustica (e9), Pattela caerulea (e5), Chiton olivaceus (e3) and slightly less Stramonita haemastoma (e19)*;

the second group is still positioned on axis 1, but opposite the first group. The species in this group are positively correlated with east coast exposure (Expos. E), extreme east location (L. EE), hard nature of the rock (RD), proximity of oil port (PPt) and fishing (PPc), and location a little further away from urban areas (ZU). These are: *Cerithium lividulum (e18), Phorcus articulatus (e12), Calliostoma zizyphinum (e21), Aplus dorbignyi (e26), Pusia tricolor (e30)*;

the third group is positioned on axis 2: the species which are positively correlated with the west location on the Oran coast (L. OC): *Pusia ebenus (e29), Gyroscala lamellosa (e27), Steromphala rarilineata (e13), Pisania striata (e16),*

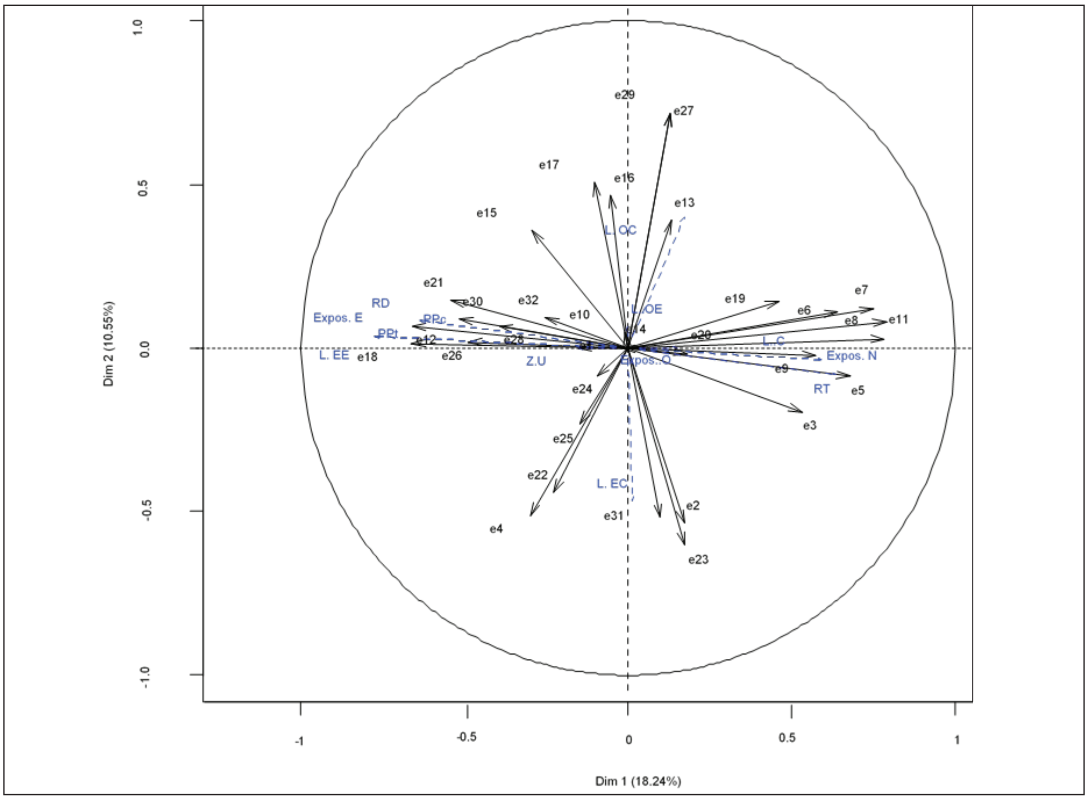


Fig. 5: Correlation circle from the principal component analysis (PCA) applied to the density of the Mollusca species with respect to environment characteristics. PPt: oil port, PPc: fishing port, ZU: urban areas, RD: hard nature of the rock, RT: tender nature (limestone) from rock L. EE: Extreme-East location, L. EC: East location, L. OC: West location, L. C: center location, L. OE: extreme-West location, Expo. E: Est exposure, Expos. O: West exposure, Expos. N: North exposure. e1, e2, …, e32: Mollusca species.
Sl. 5: Korelacijski obroč na podlagi metode PCA (principal component analysis) izračunan na temelju povezav med gostoto mehkužcev in okoljskih značilnosti. PPt: tankerska luka, PPc: ribiško pristanišče, ZU: urbana okolja, RD: trša kamnina, RT: mehkejša kamnina (apnenec), L. EE: skrajno vzhodna lokacija, L. EC: Vzhodna lokacija, L. OC: Zahodna lokacija, L. C: osrednja lokacija, L. OE: skrajno zahodna lokacija, Expo. E: vzhodna izpostavljenost, Expos. O: zahodna izpostavljenost, Expos. N: severna izpostavljenost. e1, e2, …, e32: vrste mehkužcev.

Conus ventricosus (e17). The species which are positively correlated with the east location of the Oran coast (L. EC): *Hexaplex trunculus (e31), Mytilus galloprovincialis (e23), Echinolittorina punctata (e2)*. The third group, on the other hand, is positioned relative to axis 2. It is correlated only with location (East and West), while it is indifferent to other factors. This group is divided into two subgroups;

the fourth group concerns species that are positively correlated to two axes simultaneously. Within it, two subgroups are distinguished:

Siphonaria pectinata (e4), *Bittium reticulatum (e22)*, *Cardita calyculata (e25)*. These species are not only positively correlated with (L. EC) but also positively correlated with (PPt), (PPc), (RD), (L. EE), and (Expos. E).

Columbella rustica (e15). This species is not only positively correlated with (L. OC), but also positively correlated with (PPt), (PPc), (RD), (L. EE), and (Expos. E).

Species such as *Melarhaphe neritoides (e1), Cymbula safiana (e10), Phorcus richardi (e14), Aplysia punctata (e20), Callista chione (e24), Alvania cimex (e28), Callista chione (e32)*, are too far from the correlation circle (close to the center) to be interpreted on these two axes (see other axes).

DISCUSSION

Biodiversity assessment (Spatial distribution of species diversity indices)

According to Fig. 2 and 3, the values of the Shannon index (H') at stations S1, S2, S3, and S4 are 1.62^b, 1.38^b, 1.29^b, and 1.29^b, respectively. According to Table 2, the statistical analysis (ANOVA1) reveals no significant difference ($p > 0.05$). Compared to other stations, S5 is the

most remarkable one, with a significantly lower index H' = 0.84[a] ($p < 0.001$).

Usually, an environment is considered to be unbalanced when the index remains below 0.5. The low indices observed at all stations are largely due to the abundance of two periwinkle species: *Melarhaphe neritoides* and *Echinolittorina punctata,* which colonized the wave impacted area at the mid- and supralittoral levels.

However, having the highest Shannon index H' (1.62) and the lowest Hmax (3.60), station S1 shows a rapprochement between the value of the diversity index (H') and its maximum theoretical value (Hmax). Therefore, a significantly higher evenness index (J' = 0.45)[c] confirms that this station is more balanced than the other ones.

According to Picard & Courtial (2015), a high evenness index may be due to a disturbed or recently installed ecosystem if accompanied by low biodiversity (species richness) – i.e., when the environment has a high equitability index, it is supposed to be balanced, but in the presence of low species richness this may indicate a recent environment (young). This is the case of Bouzedjar (S1), where sampling was carried out on natural rock cobs emplaced to fight the erosion of the beaches near the fishing port and at the same time prevent the silting of the port by the sand of the beach (Ghodbani, 2017). S1 is characterized (Fig. 5) mainly by the absence of *Phorcus richardi* and *Bittium reticulatum* and by a weak presence of *Melarhaphe neritoides.* It is also characterized by a strong presence of *Siphonaria pectinata* and *Cymbula safiana* compared to other stations. It should be noted that *C. safiana* is usually found in high density on harbor dykes (Frenkiel & Moueza, 1982; Rivera-Ingraham *et al.,* 2011a, c).

Regarding stations S2, S3 and S4, the statistical analysis of their respective evenness indices 0.37[bc], 0.35[b], and 0.35[b] did not show any significant difference ($p > 0.05$). This means that the Mollusca communities at these stations should be considered as similar and homogeneous. Although the absolute value of the equitability index for station S2 (J'= 0.37)[bc] seems different from that of S1 (J' = 0.45)[c], they are considered to be statistically similar ($p > 0.05$) (Tab. 3). If S2 and S4 are more or less distant from urban areas, this is not the case for S3 where dwellings are situated within a few meters of the foreshore, though most are only inhabited during the summer season.

Conversely, Arzew (S5) is visibly more polluted (Benmecheta & Belkhir, 2016). The transect area is very close to the oil and gas port of Arzew (industrial pollution). An average mercury concentration of 2.36 $\mu g\ g^{-1}$ was reported by Bouchentouf (2015) and even closer (a few meters) to housing (urban pollution). The comparison of the equitability indices revealed that station S5 (J' = 0.20) [a] had a very significant spatial heterogeneity compared to the other stations ($p < 0.001$).

On the one hand, this strong imbalance may be due to the high abundance of certain tolerant and opportunistic species, such as *Melarhaphe neritoides, Siphonaria pectinata, Phorcus articulatus,* and *Cerithium lividulum*, proliferating especially during the summer period (urban discharges). According to Pearson & Rosenberg (1978) and Grall & Coïc (2006) the peak of opportunists (with a small number of species present in high abundance) is thus expressed by low values of H' and J'. Grall & Coïc (2006) report that in the face of pollution, species will follow three types of reaction according to their sensitivity: disappear (the most sensitive), maintain abundance (the indifferent), or take advantage of the new conditions and develop (the tolerant and opportunistic). Abundance profiles over time are therefore widely used as indicators of the effects of pollutants. The profile so obtained makes it possible to identify, based on a (spatial or temporal), pollution gradient a state called "PO" corresponding to the peak of opportunists and characterized by a small number of species present in great quantities.

On the other hand, it can also correspond to an old, mature and structured stand, when a low fairness index (J' = 0.20)[a] is associated with high biodiversity (S = 21)[b]. As stated by Gosselin & Laroussinie (2004), the interpretation of the indices must always take into account the specific richness and the type of habitat. Thus, a low evenness index can correspond to a mature and structured stand with a high specific richness, while an index close to 1 can correspond to a disturbed or pioneer stand with a low specific richness.

The impact of environmental factors on species distribution (Species groupings)

The results of PCA analysis show that the presence, abundance, and proliferation of Mollusca species can be negatively or positively affected by environmental variables.

As shown in Fig. 5, the proximity of station S5 to an oil port (PPt) at the extreme east of the Oran coast (L. EE) with an east-exposure of the coast (Expos. E) and a hard rock structure (RD), favored especially tolerant and opportunistic species like *Phorcus articulatus (e12)* (A = 41 $ind.m^{-2}$, f = 52%) and *Cerithium lividulum (e18)* (A = 21 $ind.m^{-2}$, f = 39 %). These species have managed to adapt to environmental constraints, such as high concentration of organic matter, and to the tidal flats of hard rock of the upper foreshore.

Among other things we note that the proliferation of *Phorcus articulates*, unlike *Phorcus turbinatus*, seems to be due to the tolerance or even preference of this species for high concentration of organic matter. The work of Shea & Chesson (2002), Leprieur *et al.* (2008), and Beisel & Lévêque (2010) shows that changes in the environment weaken sensitive species, which begin to regress, while more tolerant species may find favorable conditions for their development in the evolution of the environment. Competition, on the other hand, would only play a marginal role.

Scientific work on the genus *Phorcus* considers this species to be an effective and reliable bioindicator of pollution (Saliba & Vella, 1977; Axiak & Schembri, 1982; Bargagli *et al.,* 1985; Nicolaidou & Nott, 1990; Cubadda *et al.,* 2001). Gueddich (2006) reported that the Trochid *Phorcus articulatus* was present in relatively

high abundance. Its distribution in the foreshore zone of the "Kerkennah" Islands (Tunisia) seems to confirm that this species is more abundant in areas potentially rich in organic matter of urban origin, as it is less present in uninhabited areas or areas with a very low rate of urban planning, like the north and east coasts of Chargui Island (Tunisia). However, pollution and hydrodynamics are certainly not the only factors governing the development and geographical distribution of *Phorcus articulatus*, other abiotic factors, such as temperature and salinity, as well as biotic factors, such as the availability of trophic resources and interactions with other populations, certainly play interesting roles as well (El Hasni, 2005).

Cerithiidae species, on the other hand, are adapted to crevices in the infralittoral and lower midlittoral. The presence of *C. lividulum* in tidal flats of the upper foreshore at Arzew may be related to previous stormy conditions. Grimes *et al.* (2004) confirm the hard nature of rock formations throughout the Cap Carbon area in the Arzew region.

We also note a positive correlation of some rare species (A < 1 ind.m^{-2}, 2% ≤ f ≤ 6%), such as: *Calliostoma zizyphinum (e21), Aplus dorbignyi (e26), Pusia tricolor (e30)*. As to *Alvania cimex (e28)* and *Peringiella denticulata (e32)*, these show an abundance of A < 1 ind.m^{-2} and a frequency of 1 ≤ ƒ ≤ 2%. The specimens of these species could be accidental arrivals in the transect area, perhaps brought in from the depths by storm waves.

On the opposite side of axis 1, in descending order, *Chiton olivaceus (e3), Phorcus turbinatus (e11), Pattela caerulae (e5), Patella ulyssiponensis (e6), Patella ferruginea (e7), Patella rustica (e8), Stramonita haemastoma (e19),* and *Fissurella nubecula (e9)* are much less present (A < 4 ind.m^{-2}, 5% ≤ ƒ < 50%) in the Gulf of Arzew and show a negative correlation with port proximity (PPt, PPc), hard substrate (RD), extreme-east location (L. EE), east coast exposure (Expos. E) and slightly less urbanized areas (ZU). This means that the increase in pollution concentration (industrial and urban pollution) inhibits the growth and proliferation of these species. Benmecheta & Lansari (2007) explain that Arzew has a mean hydrocarbon concentration of 35 mg l^{-1} (the levels of pollution reach a maximum of 107.9730 mg.1^{-1} and a minimum of 7.0977 mg 1^{-1}). Benmecheta & Belkhir (2016) have seen that levels of hydrocarbon (HC) and suspended matter (SM) in the bay of Arzew range from about 30 mg l^{-1}. Based on these facts, these species seem to be more sensitive to the negative effects of pollution (industrial and urban). On the other hand, these same species show a stronger positive correlation (indeed an affinity) to tender rock structure of (RT), north coast exposure (expos. N) and central location of the station (L. C). In addition, from the negative effect of pollution, some species, such as *S. haemastoma, P. turbinatus*, *P. articulatus* and the Patellidae, are the fishermen's preferred bait due to their large size.

S3 is characterized by a large presence of species with a frequency of ƒ > 70% and an abundance of 10 ind.m^{-2} < A <50 ind.m^{-2}, such as: *Phorcus turbinatus (e11), Pattela caerulae (e5), Patella ferruginea (e7), Patella rustica (e8), Chiton olivaceus (e3), Patella ulyssiponensis (e6)* (< 10 ind.m^{-2}) and those with a frequency of occurrence 25% < ƒ < 30%: *Fissurella nubecula (e9)* (1 ind.m^{-2} < A < 10 ind.m^{-2}) and *Stramonita haemastoma (e19)* (A < 1 ind.m^{-2}). The high abundance of *Chiton olivaceus (e3)* at this station (or even Kristel) may be due to the calcareous nature of the rock (RT), which offers good shelter to the Chitons thanks to porosity and cracks. The presence of *Aplysia punctata (e20)* noted at this station in December 2016 seems to have been accidental (ƒ < 1% and A < 1 ind.m^{-2}). According to Bay-Nouailhat (2008), *A. punctata* (the spotted sea hare) occurs from surface to more than 20 m deep and is often found stranded on beaches, among the rocks, sometimes in large numbers during the breeding season.

According to Fig. 5, the variable (L. OC) positioned on the positive side of axis 2 corresponds well to station S2. This station is characterized by the presence of a few rare species, with an abundance of A <1 ind.m-2 and a frequency of ƒ ≤ 3%, namely *Gyroscala lamellosa (e27), Pusia ebenus (29), Pisania striata (e16),* and *Conus ventricosus (e17)*; as well as by a greater presence of *Steromphala rarilineata (e13)* (A = 1 ind.m^{-2}; ƒ = 16%). *Gyroscala lamellosa (e27)* and *Pusia ebenus (29)* are exclusive, but otherwise these two species are medium-sized predatory gastropods with a worldwide distribution in marine shallow water, from New Zealand and Australia to the Mediterranean Sea and the Atlantic Ocean (Gofas, 2010).

In contrast, the variable (L. EC) positioned on the negative side of axis 2 corresponds well to Kristel (S4). This station is distinguished by the presence of species such as *Hexaplex trunculus* (e31) (A ≤ 1 ind.m^{-2}; F ≤ 1%), *Mytilus galloprovincialis (e23)* (A = 234 ind.m^{-2}, f = 18 %), and *Echinolittorina punctata (e2)* (A = 1579 ind.m^{-2}, ƒ = 93%). Indeed, these species are more abundant at S4 than at the other stations. Unlike other sites, S4 is also characterized by the strong presence of the species *Echinolittorina punctata* compared to that of *Melarhaphe neritoides* (A = 960 ind.m^{-2}, ƒ = 79%). These two periwinkle species are the two most represented species not only at S4 but also on the whole Oran coast. The high abundance of these populations is likely due to the small size of adult specimens, as they are less affected by predation. Jacques (1976) reported that the reproduction period for these species extends over several months (March, June, September and December) and the emergence of juveniles in the biotope of adults occurs in successive cohorts during the year (according to data for the period from 20 December 1971 to 10 January 1973). *Phorcus articulatus, Steromphala rarilineata*, and *Conus ventricosus* were noted as absent, although some specimens were observed near this site. *Peringiella denticulata* was noted at S4 and S5 only, while *Hexaplex trunculus* was reported only once at S4.

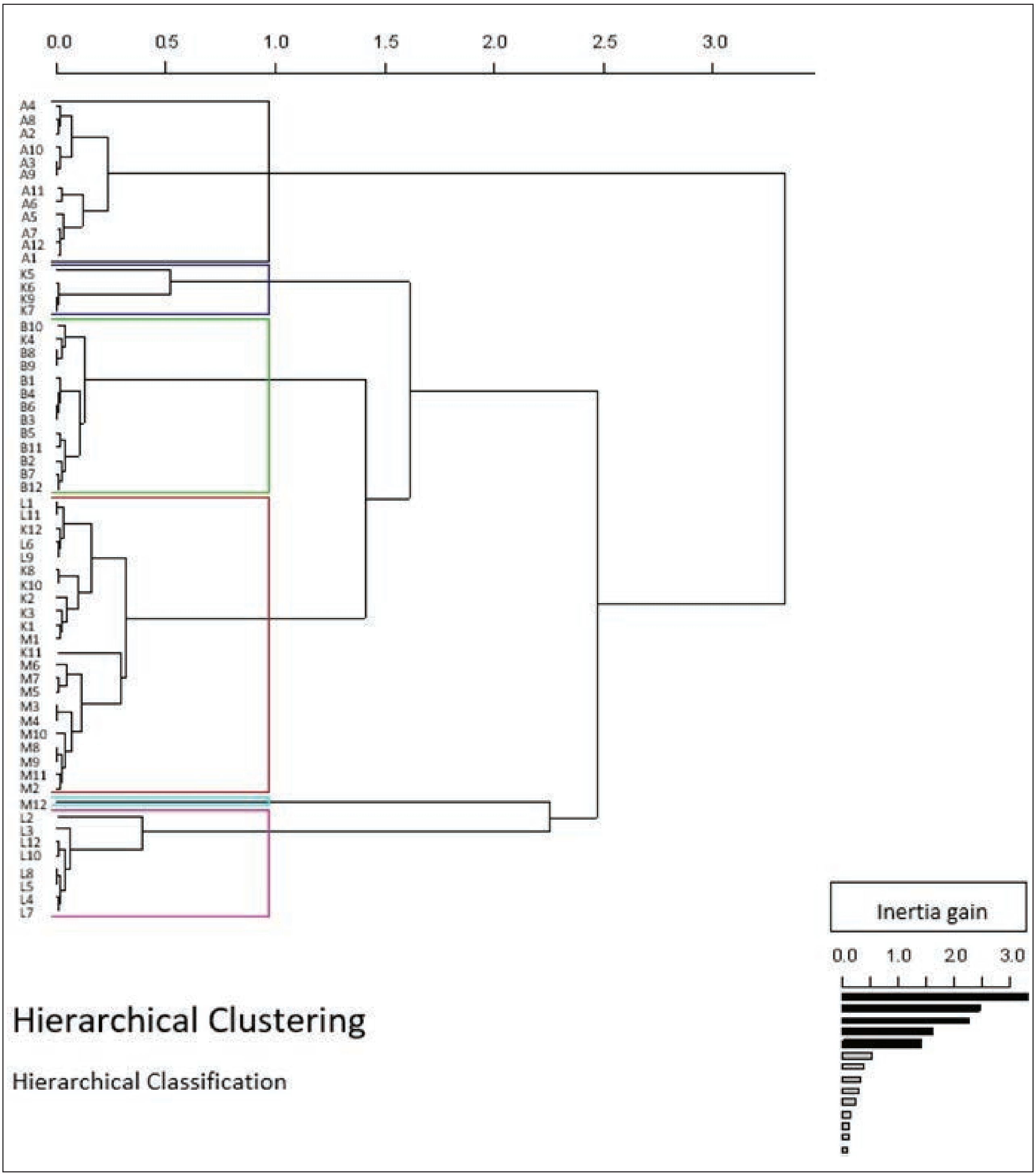


Fig. 6: Hierarchical ascendant classification (HAC) of the mollusks in Oran coast. Quadrats (sampled by month and station) are grouped together according to similarity. A: Arzew station; B: Bouzedjar station; K: Kristel station; L: La madrague station; M: Madagh station; Numbers 1, 2, 3, …, 12 : the sampling months from January to December (example: A1 is Arzew station in January).
Sl. 6: Razporeditev mehkužcev na podlagi klastrske metode HAC (Hierarchical ascendant classification) na oranski obali. Kvadrati (vzorčeni enkrat mesečno) so grupirani na podlagi podobnosti. A: vzorčevalna postaja Arzew; B: Bouzedjar; K: Kristel station; L: La madrague; M: Madagh. Številke 1, 2, 3, …, 12 : vzorčevalni meseci od januarja do decembra (primer: A1 je januarski vzorec na postaji Arzew).

As for the species *Siphonaria pectinata (e4)*, *Bittium reticulatum (e22)*, their diagonal position between two axes suggests not only a positive affinity to Kristel (L. EC) but also to Arzew (L. EE). They have a preference for the hard nature of rock (DR) and display a higher tolerance to industrial and urban pollution (PPt and PPc). On the one hand, *Siphonaria pectinata* seems to better withstand the constraints of the coastal environment since the species was often found at S1 and S5, covered with a layer of tar. On the other hand, this may be due to the nature of bedrock at these two stations, which, unlike at other stations, is hard and smooth (offers better adhesion). Steneck (1982) explains that the hardest and smoothest surfaces are the most suitable for adult individuals of certain Mollusca because they allow them to better resist the pressure of waves and predators. In addition, Rivera-Ingraham *et al.* (2011a) noted that smooth substrates had higher densities and sizes of certain species such as *C. safiana*, as opposed to heterogeneous and irregular surfaces, which can serve as shelter for young individuals and as a suitable substrate for the settlement of larvae. Finally, Boukhicha *et al.* (2014) noted that irregularities in the substrates are associated with the high recruitment rate in limpets (Patellidae) and other marine gastropod Mollusca (Littorinidae, Trochidae, etc.).

This classification groups in sets objects with a significant degree of similarity. The data studied are usually species abundances in a cross-sample/species matrix. Given the limitations of the (HAC) cited above, Fig. 6 indicates that the quadrats were grouped firstly into two groups, that of Arzew [from A1 (Arzew in January) to A12 (Arzew in December)] and that of other sites. The second group of quadrats was established according to the sites Bouzedjar, Madagh, La Madrague, and Kristel. It is clear that Arzew (left in black) is completely different from the other communities. It is also known from many studies (Boutiba, 2003; Benmecheta & Lansari, 2007; Almulsi, 2011; Meftah, 2011; and others) that Arzew is the most polluted site of the Oran coastline due to urban and industrial pollution, and the presence of petroleum port and housing nearby (a few meters away). Benmecheta & Belkhir (2016) report that despite dispersive effects, hydrocarbon (HC) concentration levels range from 90 to 180 mg/kg in surface sediments of Arzew shorelines. Sources of pollution are also found in the environmental department of the Oran province; other studies carried out on this territory of the Oran province classify the Arzew industrial zone as dangerous to environmental health. This is supported by our observations on Molluscan communities and urban discharges; oil films on sea surfaces, tar concretions on rocks, and various plastic debris were all observed during our transect survey work.

With regard to other groups, we note that station S3 in purple color, represented by quadrats L2, L3, L4, L7, L8, L10, and L12, differs from the remaining 3 groups. This site, despite the presence of nearby homes (a few meters away) remains very little frequented by summer visitors, and urban pollution is unremarkable, unlike in Arzew (S5). With regard to the last groups of quadrats, it is clear that station S1 in green color differs from the associated groups of S3 and S4 in red (Fig. 6), which, in turn, are similar. Note, however, that quadrats L1, L6, L9, and L11 for S3 are also part of this last group (consisting of stations S2 and S4).

CONCLUSIONS

As indicated by the results from the studied stations and according to the ecological indices applied, the entire Oran littoral can be considered as disturbed because the index of equitability hardly exceeds the 0.5 at any site. Despite this disturbance, results have also shown an abundance of periwinkles (very high density). These gastropods are very small and characterized by high reproduction, which considerably increases their number compared to other species. The Littorines (periwinkles) display an overall density of nearly 90% at all studied sites.

The species *Melarhaphe neritoides, Siphonaria pectinata, Phorcus articulatus,* and *Cerithium lividulum* seem to be the most resistant to adverse conditions (environmental pollution) (Gueddich, 2006) and proliferate rapidly in contrast to many other species recorded at Oran coastal stations, including *Phorcus turbinatus, Pattela caerulea, Patella ulyssiponensis, Patella Ferruginea, Patella rustica, Fissurella nubecula,* and *Cymbula safiana*. These latter species are also very sensitive to the changing environmental conditions, and can serve as an indicator of degradation of aquatic environments. Five species of Patellidae were identified in the western coast (Bouzedjar and Arzew) and 4 species in the eastern coast (Jijel and Annaba) (Beldi *et al.,* 2012; Zegaoula *et al*., 2016**;** Bouzaza, 2018; Boumaza *et al.,* 2021). *Patella ferruginosa* seems to have adapted to the Algerian western conditions area and would require further investigations in the eastern coasts.

With regard to the structure of the populations and their distributions we note that these do not only depend on the distance from the sources of pollution but also, secondarily, on the seasons (Fig. 4) and geographical coordinates of the station (Jacques, 1976; Damerdji, 2008; De Vaufleury & Gimbert, 2009; Damerdji, 2010; Diomandé, 2019).

The information presented in this document – even considering the limitations of the sampling methods increases the knowledge of the distribution and abundance of Mollusca in the Oran littoral, where pollution is identified as a key factor affecting species distributions. This new knowledge may be useful in further detailed autecology studies of Mollusca species, of species associations, and coastal ecosystem dynamics. Implementation of long-term biomonitoring in this coastal area would be of great value for the assessment of time trends related to changes in species distributions and abundances.

BIODIVERZITETA IN STRUKTURA ZDRUŽBE MEHKUŽCEV V BIBAVIČNEM OBMOČJU MED PREDELOMA BOUZEDJAR IN ARZEW (ZAHODNA ALŽIRIJA)

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POVZETEK

V raziskavi avtorji poročajo o seznamu vrst ter časovni in prostorski dinamiki združbe mehkužcev v bibavičnem pasu med predeloma Bouzedjar in Arzew v zahodni Alžiriji. V obdobju 2016 in 2017 (redna mesečna vzorčenja) so na petih vzorčevalnih postajah determinirali 32 vrst mehkužcev. Ekološki indeksi kot so abundanca (od 1167 do 2856 os. m^{-2}), število vrst (15 Gastropoda, 3 Bivalvia, in 1 Placophora), diverziteta (H') in indeks enakomernosti porazdelitve (J') kažejo, da je obalni ekosistem moten in neuravnotežen (še posebej na predelu Arzew) zaradi številnih človeških aktivnosti, ki imajo vpliv na to območje. Na podlagi raziskave je nastal zemljevid razširjenosti vrst in podatkovna baza za menedžment, biomonitoring in posledično zavarovanje obalnega ekosistema.

Ključne besede: pridneni mehkužci, bibavični pas, seznam vrst, populacijska dinamika, Alžirija

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ON THE PRESENCE OF TWO-TAILED PASHA (*CHARAXES JASIUS* (LINNAEUS, 1767), PAPILIONOIDEA: NYMPHALIDAE) IN THE NORTHEASTERN ADRIATIC REGION

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ABSTRACT

*The paper presents and discusses the first observations of two-tailed pasha (*Charaxes jasius*) in northeastern Adriatic, including first records for Slovenia. It was first noted north of its known range in Umag, Istria, in 2018, followed by an observation in Piran in 2019, Savudrija in 2020, and three observations in 2021 from well-separated localities of Strunjan, Osp, and Sela na Krasu. A search for early stages on local strawberry trees (*Arbutus unedo*) proved fruitless, indicating that the current spate of records is very likely due to the vagrant nature of the species in the region. Factors potentially limiting its range expansion, such as limited availability of the main host plant and low winter temperatures, are also discussed.*

Key words: distribution, climate change, Istria, host plants, *Arbutus unedo*

PRESENZA DELLA NINFA DEL CORBEZZOLO (*CHARAXES JASIUS* (LINNAEUS, 1767), PAPILIONOIDEA: NYMPHALIDAE) NELLA REGIONE ADRIATICA NORD-ORIENTALE

SINTESI

*L'articolo presenta e discute le prime osservazioni della ninfa del corbezzolo (*Charaxes jasius*) nell'Adriatico nord-orientale, compresi i primi dati per la Slovenia. Questa farfalla è stata notata per la prima volta a nord del suo areale conosciuto, a Umago, in Istria, nel 2018, e successivamente a Pirano nel 2019, Salvore nel 2020, e tre osservazioni nel 2021 in località ben separate: Strugnano, Ospo, e Sella delle Trincee. Una ricerca di esemplari allo stadio iniziale sui corbezzoli locali (*Arbutus unedo*) si è rivelata infruttuosa, indicando che l'attuale ondata di registrazioni è molto probabilmente dovuta alla natura vagabonda della specie nella regione. Vengono anche discussi i fattori che potenzialmente limitano la sua espansione, come la disponibilità limitata della principale pianta ospite e le basse temperature invernali.*

Parole chiave: distribuzione, cambiamento climatico, Istria, piante ospiti, *Arbutus unedo*

INTRODUCTION

The two-tailed pasha is one of the largest butterflies in Europe and the only species of the mainly Afrotropical genus *Charaxes* that reaches as far as the Mediterranean. It is distributed from the western part of North Africa (Tennent, 1996) across the Iberian Peninsula to southern France and Italy and down to the coastal areas of Greece and southern Turkey in the eastern Mediterranean (Tolman & Lewington, 2008), with isolated colonies in the Middle East (Benyamini & John 2020, Tshikolovets & Yehuda 2020). It is widespread along the east Adriatic coast, reaching as far north as the southern parts of Istria (Koren, 2012; Koren *et al.*, 2019). Along the western Adriatic coast, its occurrence, like that of its host plant, is much more sporadic reaching Mt. Conero near Ancona in the north (Teobaldelli, 1976).

The species' distribution roughly coincides with various types of Mediterranean evergreen scrubland including maqui and garrigue, where the main larval host plants, the strawberry tree *Arbutus unedo* L. and the Greek strawberry tree *A. andrachne* L., abound. On rare occasions, the larvae have also been found on other plants including bay laurel *Laurus nobilis* L. (Nel, 1979; Stefanescu, 1995), wild tea plant *Osyris quadripartita* Salzm. ex Decne. (Fernandez-Martinez, 2000), tree tobacco *Nicotiana glauca* Graham (Markis, 2003), and a range of cultivated trees including apricots (*Prunus persica* L.) and citrus trees (*Citrus* spp.) (Danner, 2001; Longo *et al.*, 2000). The species is bivoltine in most of Europe with a pronounced second generation on the wing from the second half of August to the beginning of October (Abós & Stefanescu, 1999). Despite being strong fliers, adults are generally observed near their larval habitats, although they can fly considerable distances to feed on ripe fruit, such as figs (Tolman & Lewington, 2008; Verovnik, *pers. obs.*). Males are notably territorial and both sexes are commonly observed congregating on prominent peaks, a behaviour known as "hill-topping" (Sturm, 1998; Tolman & Lewington, 2008).

Females lay conspicuous yellow eggs on the upper surface of the leaves of the host plants, and the larvae hatch within 8 to 15 days. They are not very mobile and spin a silky mat on the leaf on which they rest, which is used throughout their development to the fifth instar. They usually leave the host plant to pupate in nearby vegetation (Abós & Stefanescu, 1999). The emergence of adult butterflies follows in two to four weeks, depending on temperature. Under laboratory conditions, larvae or pupae exposed to temperatures below 5 *°C for extended periods* of time do not develop or they produce crippled individuals (Sanetra & Peuker, 1993).

The current poleward range shifts linked to climate change are becoming ever more evident in butterflies, although so far these have been more evident in regions of northern Europe and North America, which are without major topographical barriers and are more common in ecological generalist species (Parmesan *et al.*, 1999, Estrada *et al.*, 2016, Fourcade *et al.*, 2017). In our study, we present the first observations of *Charaxes jasius* in Slovenia and its close proximity, and evaluate its potential range shift northwards.

MATERIAL AND METHODS

The first observations of the two-tailed pasha were purely incidental as the authors observed the species completely unexpectedly. Deliberate surveys of potential feeding and hill-topping sites along the Slovenian coast followed. In all instances, the behaviour of adults was checked. We also surveyed the known sites where *Arbutus unedo* grows in natural habitats (Wraber, 1972; Žnidaršič, 2014) or is planted in urban areas along the Slovenian coast. Information was sought via social media regarding the distribution of strawberry tree along the Italian coast, with the search yielding several new records to add to those already known, as well as providing the location of an area of *A. unedo* (the species is not native to NE Italy) naturalised in a suitable habitat north of the village of Santa Croce-Križ in the Province of Trieste, an area that should be kept under observation in years to come.

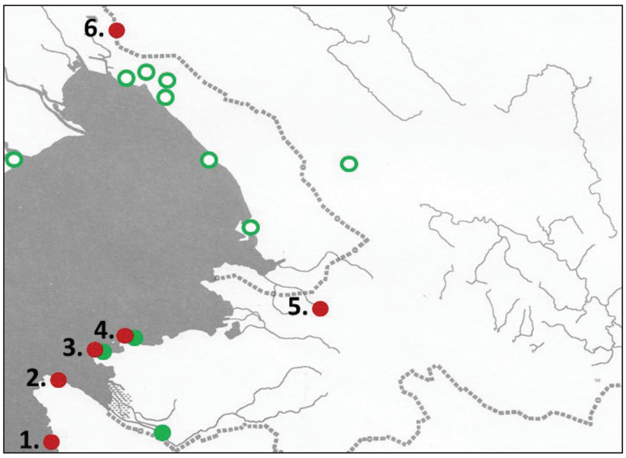


Fig. 1: The distribution of two-tailed pasha (*Charaxes jasius*) in the northeastern part of the Adriatic. The numbering of the localities follows the list in the results section. The green dots represent approximate positions of the surveyed strawberry tree (*Arbutus unedo*) stands, the empty circles denoting those that have not been checked for larvae.

Sl. 1: Razširjenost dvorepega paše (*Charaxes jasius*) v severovzhodnem delu Jadrana. Oštevilčenje sledi seznamu lokacij v Rezultatih. Zelene točke predstavljajo približen položaj pregledanih rastišč jagodičnice (*Arbutus unedo*), točke z zeleno obrobo pa lokacije, kjer prisotnost larvalnih stadijev ni bila preverjena.



Fig. 2: A male two-tailed pasha (*Charaxes jasius*) hill-topping at the peak of Mt. Kremenjak on 25 September 2021. (Photo: Kaja Milašinovič).
Sl. 2: Samec dvorepega paše (*Charaxes jasius*) na vrhu hriba Kremenjaka 25.9.2021. (Foto: Kaja Milašinovič).

RESULTS

Adults were observed at six sites in the period from 2018 to 2021. The localities are listed in geographical order from south to north (see Fig. 1):

1. Umag, within the urban area of the town, Croatia (45°26′31″N, 13°30′54″E), leg. Nejc Rabuza. A single specimen feeding on ripe figs was observed on 13 October 2018. No strawberry trees were seen in the vicinity, but they likely occur in the wider area.

2. Savudrija, the ruins of Velika stancija, Croatia (45°30′01″N, 13°30′46″E), leg. Paul Tout. A female flying around a bay laurel near the ruins was observed around noon on 16 September 2020. It was probing the leaves regularly, but no oviposition was confirmed. After a short period, it flew away. No strawberry trees were observed in the vicinity, but they likely exist in nearby urban areas.

3. Piran, above the cliff at the Church of St. George, Slovenia (45°31′47″N, 13°34′05″E) leg. Nejc Rabuza. A single specimen was briefly observed flying eastwards on 30 October 2019. As the sighting was completely unexpected, the identification is not entirely certain, although extremely likely. There are two stands of planted strawberry trees in the close proximity of the site.

4. Strunjan, at the large cross at the edge of a cliff above Moon Bay (Mesečev zaliv), Slovenia (45°32′14″N, 13°36′23″E), leg. Rudi and Jan Verovnik. A male specimen was briefly observed flying westwards along the edge of the cliff before noon on 1 October 2021. Soon afterwards, another specimen appeared flying from the inland towards the cliff, so it could have been the same individual potentially exhibiting hill-topping behaviour. No specimens were observed there an hour later. A natural population of about 20 strawberry trees (Žnidaršič, 2014) occurs on the same cliff about 300 m to the east.

5. Osp, at the upper edge of the precipitous walls above the village, Slovenia (45°34′16″N, 13°51′53″E), leg. Miro Repar. The butterfly (probably a male) was settling on bushes and low trees in the morning, on 28 September 2021. It is likely that it had spent the night at the site and was just warming up when discovered. There are no known strawberry trees in the vicinity, as the site is further inland then the others.

6. Sela na Krasu, on the peak of Mt. Kremenjak on the border with Italy, Slovenia (45°49′24″N, 13°35′33.17″E), leg. Matjaž Zadrgal. A male was seen circling an old fig and occasionally settling on nearby rocks (Fig. 2) close to the peak on 25 September 2021 in the afternoon. Given the prominence of the peak and considerable time the observed specimen spent there, it is likely that it was exhibiting hill-topping behaviour. There are no strawberry trees in the vicinity, but the coast of Duino, where planted

specimens are known (Zadrgal, M. and Tout, P., *pers. obs.*), is only about 4 km away.

The following localities were also inspected based on the abundance of fig trees and/or their prominence, but without success: Seča (45°29′53″N, 13°36′25″E), Cape Seča (45°30′07″N, 13°35′22″E), Cape Ronek (45°32′17″N, 13°36′49″E), Tinjan (45°33′40″N, 13°50′07″E), and Socerb castle (45°35′21″N, 13°51′40″E).

In addition, the natural stand of strawberry trees in Cape Ronek above the cliffs (45°32′22″N, 13°36′49″E) was inspected for early stages. Only three trees were accessible at the site, all already overshadowed by nearby oaks and partially overgrown with *Smilax aspera* L. Despite that, the trees looked vital with both flowers and fruits present. No larvae or eggs were found on visible parts of the trees, however leaf damage on the terminal parts of the branches similar to what *Charaxes jasius* (Abós & Stefanescu, 1999) is known for was evident, but it might have been caused by other herbivorous insects. Larvae were also searched for, unsuccessfully, at two sites within urban area of Piran (45°31′43″N, 13°34′18″E and 45°31′33″N, 13°34′21″E) and in the Dragonja Valley at Stena (45°27′08″N, 13°39′38″E), a very well-known refugium for Mediterranean plants (Wraber, 2002).

DISCUSSION

Despite permanent populations of *Charaxes jasius* on the west coast of Istria, Croatia, as far north as Palud, south of Poreč (Koren 2012), no historical records are known for the Slovenian and Italian parts of the Istria coast (see overview in Stauder, 1922). This is rather surprising given the odd record of the species as far north as Styria (Austria) near Graz, which might however have resulted from a released reared specimen (Habeler, 1983). Given the concise effort to map the distribution of butterflies in Slovenia over the last two decades (Verovnik *et al.*, 2012), it is hardly likely that the species had been overlooked, which means that the present sightings are indeed the first in the studied region. Although the almost perfect sequence of occurrences further north each year might be entirely coincidental, it still shows a trend for the species to expand northwards. The autumn of 2021 proved exceptional, with the three independent occurrences spread across a wide area potentially indicating a more numerous invasion. Breeding, which would indicate an attempt of colonization, remains to be confirmed.

Whether our observations indicate a leading edge of the species' expansion is yet to be seen. A similar local northward expansion, linked with planted ornamental strawberry trees, has been noted in Madrid province in central Spain, which has a more continental climate (Cancela & Vasconcelos, 2019). However, the population of strawberry trees at sites where breeding of *Charaxes jasius* was confirmed is much larger than anywhere else in the studied region. The sparseness of the main host plant along Slovenian and Italian coasts of the Northern Adriatic may be one of the major factors inhibiting permanent colonization by this species. However, no in-depth survey of the distribution of the strawberry tree, especially in urban areas, has so far been conducted in Slovenia or in neighbouring parts of Italy. Such survey might somewhat change the picture, as would the potential utilization of *Laurus nobilis* (seen Stefanescu, 1995), which is much more widespread in the region. The female observed assessing the bay laurels in Savudrija certainly points in this direction.

The other major factor is the climatic conditions, especially for larvae overwintering on the host plants. These are quite thermophilous and require temperatures above 11.5 °C for successful foraging (Abós & Stefanescu, 1999). In addition, extended periods bellow 5 °C can prove detrimental to the early instars, especially pupae (Sanetra & Peuker, 1993). The only climatic data available for the coastal part of Slovenia are from the Portorož Airport and suggest that half of the past 10 winters might have been too cold for the development and survival of *Charaxes jasius,* with average January temperatures below 5 °C, and average minimum temperatures below zero on three occasions (ARSO Meteo, 2021). However, this particular weather station is positioned on the valley floor and thus likely to be exposed to colder conditions than the steep slopes on which the strawberry trees grow.

Whether *Charaxes jasius* will become a common sight along the northern coast of Istria or not remains to be seen, but several steps could be taken to successfully trace its potential expansion. Using baited traps in early autumn (see Abós & Stefanescu, 1999) at sites with strawberry trees might be an efficient way to discover whether females are able to find the host plants and facilitate the finding of the early stages. Long-term temperature measurements at these sites would also be useful to see if the microclimatic conditions allow larval survival over winter. Additionally, a more comprehensive survey of the distribution of strawberry trees would be needed, as well as promotion of their ornamental and culinary value for their wider use in the region. To conclude, we believe that the species is currently only a vagrant to the area under study, but that might change in a not so distant future.

ACKNOWLEDGMENTS

The authors are grateful to those who provided information on the distribution of *Arbutus* species within Italy in the area covered by the study (via the Facebook Group *Misteri & Meraviglie del Carso*, Giorgio Cusma, Graziella Longo, Elisa Comelli, Carla Pierangelini, Matteo Skodler and Paolo Utmar) and Kaja Milašinovič for allowing the publishing of the photograph of an adult at Mt. Kremenjak. The first author is grateful to Jan Verovnik for his help during fieldwork.

O POJAVLJANJU DVOREPEGA PAŠE (*CHARAXES JASIUS* (LINNAEUS, 1767), PAPILIONOIDEA: NYMPHALIDAE) NA OBMOČJU SEVEROVZHODNEGA JADRANA

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POVZETEK

*V raziskavi predstavljamo in obravnavamo prva opazovanja dvorepega paše (*Charaxes jasius*) na območju severovzhodnega Jadrana, vključno s prvimi najdbami v Sloveniji. Vrsta je bila prvič opažena severno od znanega območja razširjenosti v Istri v Umagu leta 2018, sledilo je opazovanje v Piranu leta 2019, Savudriji leta 2020 in tri opazovanja leta 2021 iz precej oddaljenih najdišč pri Strunjanu, Ospu in Selah na Krasu. Iskanje larvalnih stadijev na lokalnih jagodičnicah (*Arbutus unedo*) se je izkazala za neuspešno, kar kaže na trenutno zelo verjetno nestalno naselitev vrste v regiji. Razpravljamo še o potencialnih dejavnikih, ki bi lahko predstavljali omejitev za širitev vrste, na primer omejena razpoložljivost glavne gostiteljske rastline in nizke zimske temperature.*

Ključne besede: razširjenost, podnebne spremembe, Istra, gostiteljske rastline, *Arbutus unedo*

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NEW RECORDS OF NON-BITING MIDGES (DIPTERA, CHIRONOMIDAE) FROM MARINE AND COASTAL HABITATS OF THE SLOVENIAN PART OF THE ADRIATIC SEA

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ABSTRACT

Based on the samples taken from the marine shore and two coastal lagoons at three locations along the Slovenian part of the Adriatic coast, 4 species of non-biting midges (Diptera, Chironomidae) were determined, Thalassomya frauenfeldi *Schiner, 1856,* Halocladius (Halocladius) variabilis *(Staeger, 1839),* Halocladius (Halocladius) varians *(Staeger, 1839) and* Chironomus (Chironomus) salinarius *Kieffer, 1915. All four species represent first records from marine and lagoon environments, to be added to 28 previously recorded species for Slovenia. As nearby Croatia is being Chironomidae biodiversity hotspot, we can expect numerous species of Chironomidae yet to be discovered in Slovenia and hopefully this research will be a steppingstone for further chironomid research.*

Key words: chironomids, Adriatic Sea, *Thalassomya frauenfeldi, Halocladius variabilis, Halocladius varians, Chironomus salinarius*

NUOVI RITROVAMENTI DI MOSCERINI CHIRONOMIDI (DIPTERA, CHIRONOMIDAE) IN HABITAT MARINI E COSTIERI DELLA PARTE SLOVENA DEL MARE ADRIATICO

SINTESI

In base ai campioni prelevati lungo la riva e in due lagune costiere, in tre località della parte slovena della costa adriatica, sono state determinate 4 specie di moscerini chironimidi (Diptera, Chironomidae), Thalassomya frauenfeldi *Schiner, 1856,* Halocladius (Halocladius) variabilis *(Staeger, 1839),* Halocladius (Halocladius) varians *(Staeger, 1839)* e Chironomus (Chironomus) salinarius *Kieffer, 1915. Tutte e quattro le specie rappresentano i primi ritrovamenti in ambienti marini e lagunari, che si aggiungono alle 28 specie precedentemente registrate in Slovenia. Poiché la vicina Croazia è un punto caldo per la biodiversità dei Chironomidi, possiamo aspettarci numerose nuove specie da scoprire in Slovenia, e speriamo che questo studio sia un punto di partenza per ulteriori ricerche sui chironomidi.*

Parole chiave: chironomidi, Adriatico, *Thalassomya frauenfeldi, Halocladius variabilis, Halocladius varians, Chironomus salinarius*

INTRODUCTION

Non-biting midges (Diptera, Chironomidae) are among the most abundant and diverse groups of the extant insects (Armitage *et al.*, 1995). Larvae of most Chironomidae species are inhabiting freshwater, occupying variety of available microhabitats (Ferrington, 2007). Small number of taxa, among over 7000 described species (Ashe and O'Connor, 2009), are however inhabiting saline, hypersaline and marine habitats (Armitage *et al.*, 1995). Marine Chironomidae are inhabiting coastal areas, being associated with algal mats on the rocks in the intertidal zone (Kaiser *et al.*, 2021). These Chironomidae larvae are playing important role in the maintaining of the matter and energy flow in the coastal habitats and represent important indicators of the environmental status (Armitage *et al.*, 1995; Ferrington, 2007). Therefore, understanding the coastal Chironomidae fauna is crucial for monitoring and conservation of the coastal areas (Neumann et al., 1997).

Unfortunately, the Chironomidae fauna of the Slovenian part of the Adriatic coast is poorly known, as most studies of the Chironomidae in Slovenia concentrated on the paleolimnological studies of the alpine lakes, and lake Bled in particular (Andrič *et al.*, 2009), impact of the mining on the benthic organisms (Trontelj & Ponikvar-Zorko, 1998) as well as biomonitoring of the alpine riverine systems (Mori & Brancelj, 2006, 2011). According to Fauna Europea, only 28 species of Chironomidae are formally recorded from Slovenia (Sæther & Spies, 2011).

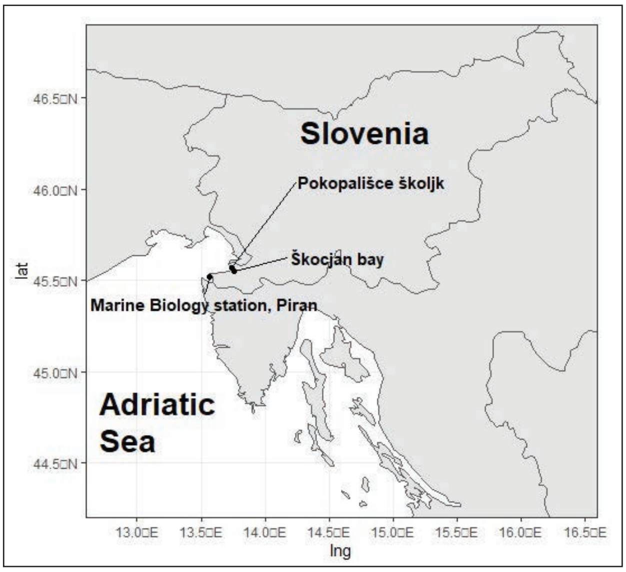


Fig. 1: Sampling locations along Slovenian coast of the Adriatic Sea included in the research.
Sl. 1: Vzorčevalne postaje vzdolž slovenske jadranske obale, ki so bile zajete v raziskavi.

Tab. 1: Sampling sites and sampling methods for the collection of the material used in the paper.
Tab. 1: Vzorčevalne postaje in metode zbiranja materiala, uporabljenega v tej raziskavi.

Site	Sampling method	Sampling period	Latitude	Longitude
Marine Biology Station NIB, Piran, rocky shore and concrete steps	Selective hand sampling, from the depth cca. 10 cm	2nd September 2019	45.52°N	13.57°E
Tanatocenosis Ankaran, algal mat	Selective hand sampling, from the depth ca. 10-20 cm	3rd September 2019	45.57°N	13.74°E
Lagoon of Škocjanski zatok Nature Reserve, Koper, soft sediments	Benthic grab (0.045 m^2) at cca. 50-100 cm depth	winter and summer 2009, summer 2011, winter 2012, winter and summer 2018	45.55°N	13.75°E

Although Chironomids are known to be very abundant in the Slovenian coastal lagoons, no formal species records exist (Pitacco *et al.*, 2018). An unidentified species of the *Halocladius* was previously recorded from the Salines of Sečovlje National Park (Juteršek & Dolinar, 2021).

In this communication, we are presenting new records of the Chironomidae from the Slovenian coastal area.

MATERIAL AND METHODS

Material was collected near Marine Biology Station (Piran), at the Ankaran Tanatocenosis beach and in the Lagoon of Škocjanski zatok, near Koper, utilizing array of the hydrobiological methods (manual collection from the substrate in first two locations and benthic grab in the third). More details are provided in the Table 1 and Figures 1 and 2. All studied specimens were mounted into the Fore-Berlese medium as described by Salmon (1947).

Specimens were imaged using a Keyence VHX-6000 Digital microscope, with a ring-light type illumination. All images were recorded as composites, to achieve the required depth of focus. Images were stitched and stacked to overcome the limitation of the width of the field of view, using in built software of the digital microscope (Haug & Ehrlich 2008; Haug *et al.*, 2011, 2013). Specimens were identified using following keys: Hirvenoja (1973), Cranston (1983) and Orendt *et al.* (2013).

Voucher material is preserved in the collection of the Marine Biology Station of the National Institute of Biology (Piran, Slovenia).

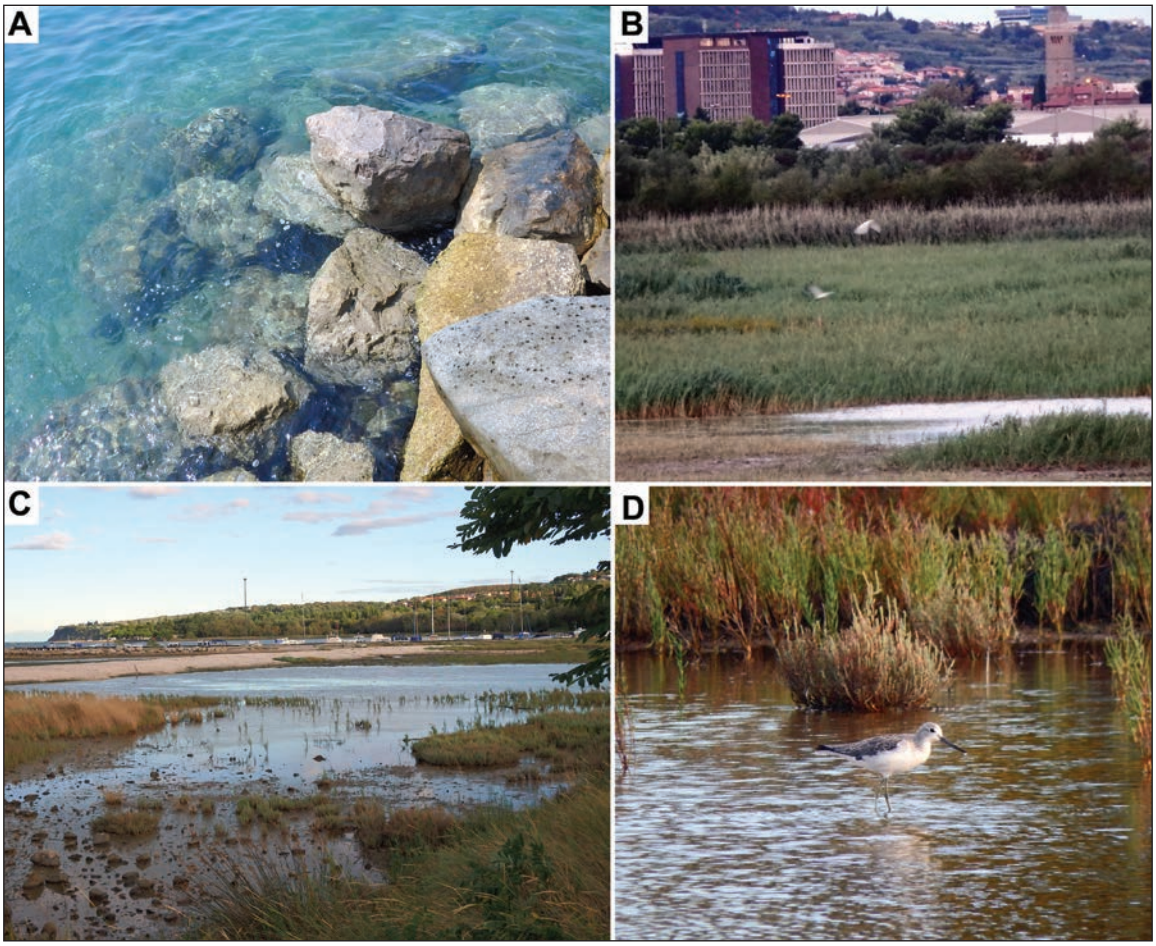


Fig. 2: Coastal habitats of Chironomidae representatives on the Slovenian Adriatic coast: A. Rocky shore next to Marine Biology Station NIB, Piran; B. Škocjanski zatok Nature Reserve, Koper; C. Ankaran tanatocenosis, Ankaran; D. Some of the Chironomidae habitats are among the most important Adriatic coastal wetlands – lagoon at tanatocenosis Ankaran with common greenshank (*Tringa nebularia*) in the center.
Sl. 2: Obrežni habitati, kjer so bile najdene vrste trzač na slovenski jadranski obali: A. Skalnata obala pred Morsko biološko postajo NIB, Piran; B. Naravni rezervat Škocjanski zatok, Koper; C. tanatocenoza v Ankaranu; D. Nekateri habitati, kjer so bile najdene trzače, so med najpomembnejšimi jadranskimi obrežnimi mokrišči – laguna pri tanatocenozi v Ankaranu z zelenonogim martincem (*Tringa nebularia*) v ospredju.

RESULTS AND DISCUSSION

Four species of chironomids were found in the inspected material, all of them being new record for Slovenia.

Chironomidae Newman, 1834
Telmatogetoninae Wirth, 1949
Thalassomya frauenfeldi Schiner, 1856

Two second instar and seven 4th instar larvae were collected on the concrete steps and stones (about 1m x 40 cm), leading into the sea, directly in front of the Marine Biological Station's building, on 2nd of September 2019 (Fig. 3). Larvae where handpicked from the substrate.

Distribution notes: *T. fauenfeldi* is widely distributed in Europe, in countries around Mediterranean, Black, Baltic and North seas, as well as at the Canary Isles (Ashe & O'Connor, 2009). Adult animals are short-lived, inhabiting the wet rocks in the intertidal zone, while larvae are developing at the algal mats in the supralittoral zone (Cranston, 1983).

Orthocladiinae Lenz, 1921
Halocladius (*Halocladius*) *variabilis* (Staeger, 1839)

Two 4th instar larvae were collected on the concrete steps, leading into the sea, directly in front of the Marine Biological Station's building, on 2nd of September 2019.

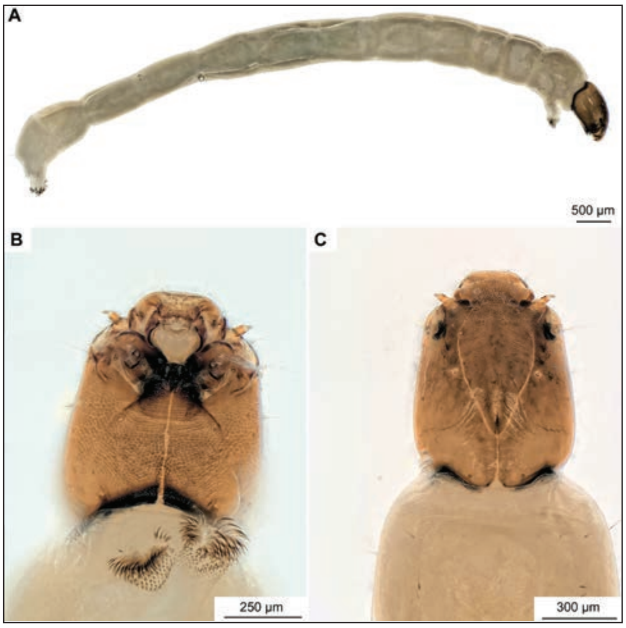


Fig. 3:** Thalassomyia frauenfeldi**. A. Habitus of the 4th instar larva; B. Head capsule, ventral view; C. Head capsule, dorsal view.

Sl. 3:** Thalassomyia frauenfeldi**. A. Ličinka v četrtem stadiju; B. Glava, ventralni pogled; C. Glava, dorzalni pogled.

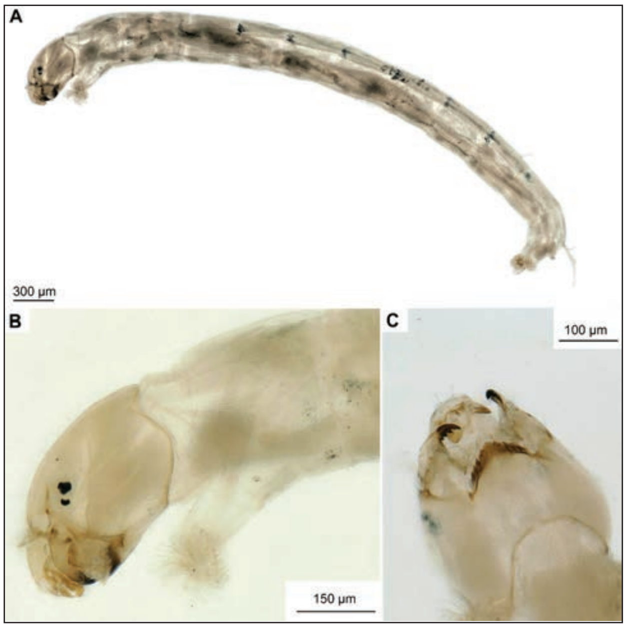


Figure 4.** Halocladius varians**. A. Habitus of the 3rd instar larva; B. Head capsule, lateral view; C. Head capsule, ventral view.

Sl. 4:** Halocladius varians**. A. Ličinka v tretjem stadiju; B. Glava, bočni pogled; C. Glava, ventralni pogled.

Distribution notes: *H. variabilis* is widely distributed in North America (USA, Canada, Greenland) and Europe, in the countries surrounding the Black, Mediterranean, Nort and Baltic seas, as well as at the Azores, Balearic, Faroe Isles, Great Britain and Iceland (Ashe & O'Connor, 2012). Larvae of the species are inhabiting predominantly rocky environments, routinely inhabiting the rock pools at the sea shore, as well as ports and sea-side channels (Hirvenoja, 1973; Moller Pillot, 2013).

Halocladius (*Halocladius s.str.*) *varians* (Staeger, 1839)

Three 2nd and 3rd instar larvae (Fig. 4) were sampled by a benthic grab at the lagoon of Škocjanski zatok Nature Reserve, Koper in 2011, and by hand from the shore algal mats at the Ankaran thanatocenosis on 3rd of September 2019.

Distribution notes: *H. varians* is widely distributed in North Africa (Morocco), Near East (Lebanon) and Europe, in the countries surrounding the Black, Mediterranean, North and Baltic seas, as well as at the Azores, Madeira, Great Britain and Irealand (Ashe & O'Connor, 2012). Adult animals are short-lived, swarming in large quantities next to the sea-side buildings and structures (Moller Pillot, 2014). Larvae are inhabiting long tubes on stones, plants and other structures, in the intertidal area, next to the low-water mark (Moller Pillot, 2013). In addition to the brackish and marine water, larvae are also free-living in the polluted freshwater, i.e. in the lower course of river Rhine (Hirvenoja, 1973). *H. varians*, were probably the chironomids recorded by Juteršek & Dolinar (2021) as phytophagous on the algal mats at the Salines of Sečovlje National Park. We came to this conclusion, based on the photos of the specimens involved in the study of Juteršek & Dolinar (2021), clearly showing the sand tubes similar to ones built by *H. varians*, as well as larvae and adult flies, very similar to *H. varians* (Juteršek & Dolinar (2021, fig. 2a-g). In the work of this authors, larvae of the chironomids in question were destroying the microbial mats, involved in the traditional process of the salt production at the the Salines of Sečovlje National Park (Juteršek & Dolinar, 2021).

Chironominae Macquart, 1838
Chironomini Macquart, 1838
Chironomus (*Chironomus s.str.) salinarius* Kieffer, 1915

Numerous 4th instar larvae were sampled by a benthic grab at the lagoon of Škocjanski zatok Nature Reserve, Koper on each sampling period. In the benthic samples from the lagoon *Ch. salinarius* larvae can account even to 1/3 of all benthic organisms present (Fig 5C-F) Pitacco *et al.*, 2018).

Distribution notes: Slovenia was the only European country with the access to either Mediterranean, Black Sea or Baltic coast not to have *Ch. salinarius* previously recorded (Moller Pillot, 2009). Taking into account

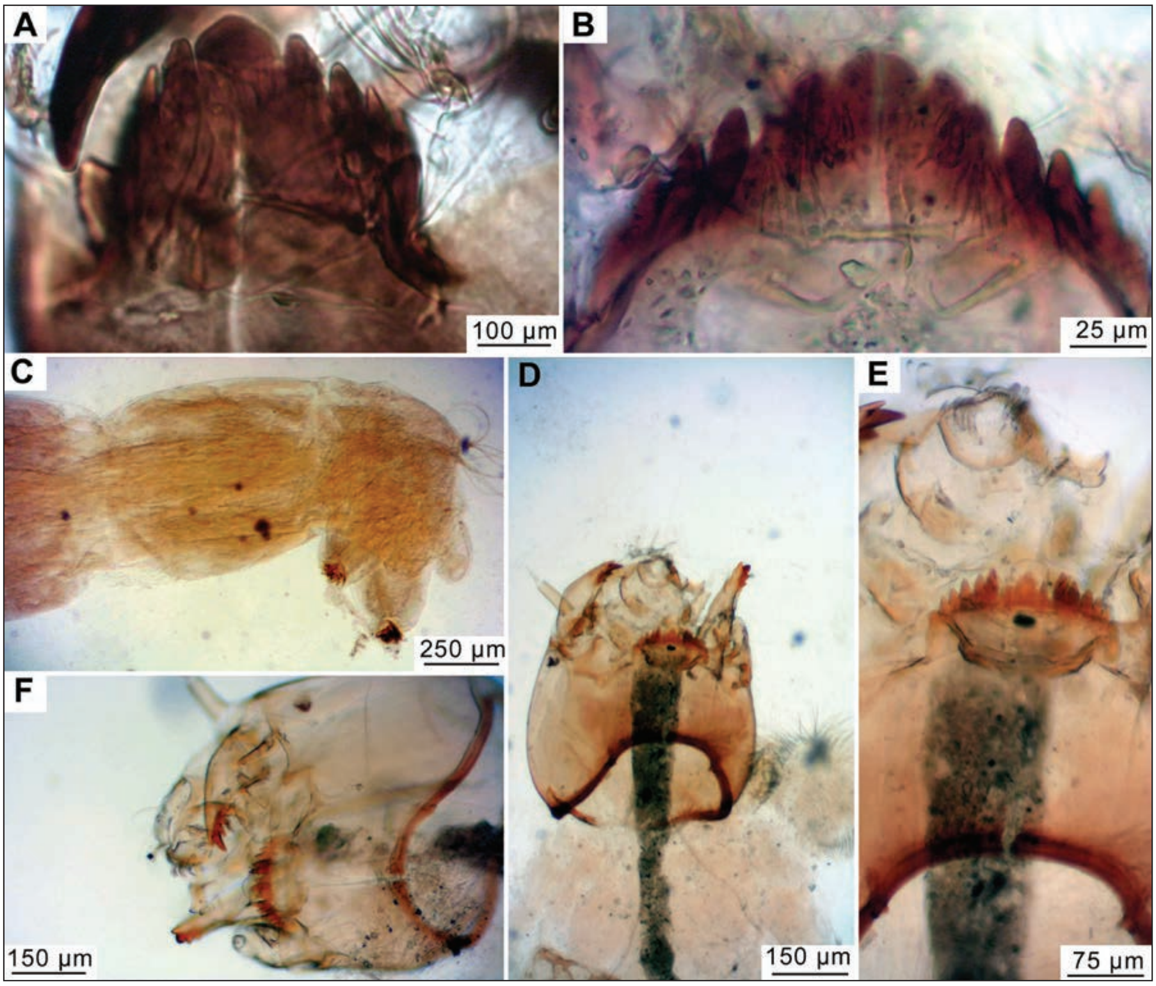


Figure 5.** Halocladius variabilis, **A-B;** Chironomus salinarius, **C-F. A. Ventral side of headcapsule of the 3rd instar larva; B. Mentum, ventral view; C. End of abdomen; D. Head capsule, ventral view; E. Mentum, ventrally; F. Mentum and mandibles, ventrally.
Sl. 5:** Halocladius variabilis, **A-B;** Chironomus salinarius, **C-F. A. Ventralna stran glave ličinke v tretjem stadiju; B. Mentum, ventralni pogled; C. Zadnji del abdomna; D. Glava, ventralno; E. Mentum, ventralno; F. Mentum in čeljustnici, ventralno.

abundance of *Ch. salinarius* in northern Adriatic region, it is hardly a surprise that we have found this species in Slovenia. Species appears to play an important role in the brackish lagoons of Slovenia, due to their local abundance (Pitacco *et al*., 2018), by playing the part in the cycling of the organic matter and carbon sequestration (Baranov *et al*., 2016).

CONCLUSIONS

This short study shows that large proportion of Chironomidae fauna of Slovenia is not recorded yet. For example, Luxembourg, with over 10 times lower surface area than Slovenia (998 km2 vs 7,827 km^2 respectively) has 154 species of Chironomidae recorded (Saether & Spies, 2011). Taking into account, that nearby Croatia turned out to be a Chironomidae biodiversity hotspot (Giłka *et al*., 2013; Andersen *et al*., 2016; Ivković *et al*., 2015, 2020; Čerba, 2020; Dorić *et al*., 2021), we can expect numerous species of Chironomidae yet to be discovered in Slovenia. These studies will help both development of the hydrobiological research and water quality monitoring of Slovenia.

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NOVE NAJDBE TRZAČ (DIPTERA, CHIRONOMIDAE) IZ MORSKIH IN OBMORSKIH HABITATOV V SLOVENSKEM DELU JADRANA

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POVZETEK

V vzorcih iz morskega obrežja in dveh obalnih lagun na treh lokalitetah vzdolž slovenskega dela Jadrana sta avtorja določila štiri vrste trzač (Diptera, Chironomidae), Thalassomya frauenfeldi *Schiner, 1856,* Halocladius (Halocladius) variabilis *(Staeger, 1839),* Halocladius (Halocladius) varians *(Staeger, 1839) in* Chironomus (Chironomus) salinarius *Kieffer, 1915. Vse štiri vrste predstavljajo prve najdbe iz morskih in lagunskih okolij v Sloveniji, ki dopolnjujejo seznam 28 predhodno potrjenih vrst za Slovenijo. Glede na dejstvo, da je bližnja Hrvaška vroča točka diverzitete trzač, avtorja pričakujeta, da bodo v prihodnosti potrjene številne vrste iz družine Chironomidae, ta prispevek pa kot začetni korak za prihodnje raziskave trzač.*

Ključne besede: trzače, Jadransko morje, *Thalassomya frauenfeldi, Halocladius variabilis, Halocladius varians, Chironomus salinarius*

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LE ORCHIDACEAE DEL SITO DI INTERESSE COMUNITARIO "MONTE PALLANO E LECCETA D'ISCA D'ARCHI" E DELLE ZONE LIMITROFE

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SINTESI

Il Sito SIC/ZSC "Monte Pallano e Lecceta d'Isca d'Archi" si trova interamente in Abruzzo ed in particolare nella provincia di Chieti. Il suo territorio che copre la superficie di 3270 ha, è molto eterogeneo e presenta un'elevata diversità floristica con circa 1250 taxa di piante vascolari segnalate. Nel presente saggio, considerando gli studi sinora condotti e le ricerche sul campo degli autori è stato compilato un nuovo elenco di tutte le Orchidaceae presenti cui è seguita l'analisi corologica che evidenzia una prevalenza del contingente Mediterraneo. Nell'elenco floristico sono riportati 47 taxa distinti tra specie e sottospecie. Esso comprende anche 7 specie endemiche che accrescono l'importanza fitogeografica dell'area di studio.

Parole chiave: Monte Pallano, Orchidaceae, Abruzzo, Italia Centrale, check-list, spettro corologico

THE ORCHIDACEAE OF THE SITE OF COMMUNITY INTEREST "MONTE PALLANO AND LECCETA D'ISCA D'ARCHI" AND THE NEIGHBORING AREAS

ABSTRACT

The "SCI/SAC" Monte Pallano and Lecceta d'Isca d'Archi" site is located entirely in Abruzzo and in the province of Chieti. Its territory which covers an area of 3270 ha is highly heterogeneous and has an elevated floristic diversity with about 1250 taxa of vascular plant species reported. In this article, considering the studies conducted so far and the field research of the surveys of the authors, a new list of Orchidaceae has been compiled. The chorological analysis shows a prevalence of the Mediterranean contingent. The checklist reports 47 taxa. It also includes 7 endemic species that increase the phytogeographic importance of the study area.

Key words: Monte Pallano, Orchidaceae, Abruzzo, Central Italy, check-list, chorological spectrum

INTRODUZIONE

Le orchidee spontanee sono piante che per la bellezza e la complessa biologia suscitano un notevole interesse e sono osservate e studiate da amatori, botanici professionisti, singolarmente o in gruppi organizzati. Tenendo conto della loro importanza e della necessità di approfondire la conoscenza, nel presente saggio si è voluto compilare una checklist comprendente tutte le entità rinvenute nel territorio Sito SIC/ZSC "Monte Pallano e Lecceta d'Isca d'Archi" di cui attualmente non esiste nessun lavoro monografico specifico riguardante tale famiglia di piante.

Inquadramento dell'area d'indagine

Il sito SIC/ZSC "Monte Pallano e Lecceta d'Isca d'Archi" IT7140211 si trova in Provincia di Chieti (Abruzzo), è stato istituito nel 2003 e ha avuto in assegnazione il codice europeo IT7140211. Esso è tutelato oltre che dalla Rete Natura 2000 istituita dalla Comunità Europea per salvaguardare le eccellenze della biodiversità presenti negli Stati nazionali, anche dalle DGR n. 279/2017 e DGR n. 492/2017 che prevedono misure generali e specifiche per la conservazione degli habitat e la salvaguardia delle specie di particolare pregio. Con la Delibera della Giunta Regionale (DGR) 476 del 05/07/2018, il sito è stato riconosciuto anche ZPS (Zona di Protezione Speciale) in base alla "Direttiva Uccelli" perché ricadente all'interno dell'area IBA (Important Bird Areas) 115.

Il suo territorio occupa la superficie complessiva di 3270 ha, presenta un'escursione altitudinale che va da 145 m s.l.m. del ponte Malpassaggio d'Isca d'Archi (Valle del Sangro) a quella massima di 1.020 metri della cima del Monte Pallano (entrambe le quote sono poste nel territorio comunale di Bomba) ed è ripartito tra cinque Comuni: Archi (812 ha), Atessa (446 ha), Bomba (832 ha), Colledimezzo (312 ha) e Tornareccio (868 ha) (Pellegrini *et al*., 2014, 2018).

L'ambito di studio comprende varie zone collinari e il Monte Pallano, un rilievo calcareo situato interamente in provincia di Chieti. La sua vetta rappresenta la parte più elevata di una dorsale che dalla piana alluvionale del Sangro si sviluppa lungo un crinale che tocca i territori comunali di Archi, Bomba, Tornareccio, Colledimezzo, Monteferrante, Roio del Sangro, Montazzoli e, infine termina nel Comune di Castiglione Messer Marino con il Monte Castel Fraiano posto a un'altitudine di 1415 metri (Pellegrini *et al*., 2018).

Nel Monte Pallano sono evidenti vari fenomeni carsici che hanno portato alla formazione di numerose doline tra cui la più grande è quella di Lago Nero, una lunga depressione di circa 450 metri che durante le annate con abbondanti precipitazioni si riempie d'acqua favorendo la formazione di un lago stagionale ed effimero che può raggiungere la profondità di circa 6 metri (Cicchitti & Pellegrini, 2014). La sua particolare denominazione è dovuta alla colorazione scura che assumono le acque a causa dell'ombra proiettata dalla vegetazione arborea circostante. La formazione del lago di solito inizia nel mese di marzo, appena dopo il disgelo, raggiunge la massima estensione tra fine aprile e i primi giorni di maggio, mentre tra giugno e gli inizi di luglio si ha il suo prosciugamento totale (Cicchitti & Carunchio, 1999).

Il Monte Pallano è sede anche di un importante complesso archeologico italico-sannita risalente al IV-V secolo a. C. che è stato identificato con l'antica città di Pallanum (Cicchitti *et al*., 1996; Cicchitti & Pellegrini, 2014).

L'assetto geomorfologico dell'ambito di studio è caratterizzato dalla presenza di vari domini paleogeografici formatisi nel corso d'ere geologiche diverse, modificati e rimodellati da vari eventi tettonici e processi morfologici (Pellegrini *et al*., 2014, 2018). In particolare, dal punto di vista geologico l'area del Monte Pallano, è caratterizzata da una successione oligo-miocenica in ricoprimento tettonico su terreni d'origine pliocenica (Selli, 1962).

Ad avviso di Pellegrini *et al*. (2014, 2018), le principali formazioni rocciose presenti nel sito SIC/ZSC sono le seguenti:

- rocce calcaree e calcareo-marnose appartenenti alle unità carbonatiche del massiccio della Majella e dell'avanfossa periadriatica;
- sedimenti argillosi noti come "Argille Varicolori", depositatesi tra l'Oligocene e il Miocene inferiore;
- il "*Flysh di Roccaspinalveti*" che si è originato durante il Messiniano ed è costituito da strati alternati di marne argillose e arenarie con intercalazioni di calcareniti;
- la "*Formazione di Tufillo*" che risale al Tortoniano-Langhiano ed è costituito da calcilutiti marnose bianche con intercalazioni di siltiti, marne argillose bluastre e intervalli di prevalenti calcareniti;
- calciruditi e microconglomerati a biocalcareniti torbiditiche.

Per quanto riguarda l'area occupata dalle acque del Lago Nero, le indagini geognostiche di Tullo & Apilongo (2006) hanno evidenziato la presenza di: 1) uno strato superficiale di terreno vegetale variabile tra 1 e 2 m di spessore; 2) uno strato intermedio più in basso dallo spessore compreso tra 4 e 10 metri di limo argilloso con nuclei di carbonato di calcio e carboniosi, livelli sabbiosi e frammenti calcarei abbastanza estesi; 3) uno strato roccioso più profondo costituito da marna calcarea fratturata.

Nell'area del SIC/ZSC, il reticolo idrografico è costituito da diversi piccoli torrenti e ruscelli secchi per gran parte dell'anno che affluiscono nei fiumi Sangro, Osento e Sinello.

Il clima

All'interno del sito SIC/ZSC non sono presenti stazioni meteorologiche e di conseguenza per la definizione del clima locale si farà riferimento ai dati termo-pluviometrici raccolti in quelle dei comuni in cui è compreso.

Dalla consultazione di una tesi di laurea (Gallucci, 2002) e alcune pubblicazioni (Conti & Pirone, 1992; Di Lena *et al.*, 2017; Giuliani & Antenucci, 2017; Pellegrini *et al.*, 2018) è emerso che i dati termo-pluviometrici di alcuni Comuni e particolari ambiti situati all'interno dell'area SIC/ZSC assumono i seguenti valori:

- ad Archi la temperatura media annua è di 13,4°C; la temperatura media mensile oscilla tra 5,5°C (gennaio e febbraio) e 23°C (agosto); la temperatura minima assoluta si registra a febbraio con -4°C, mentre quella massima a luglio con 37°C; le precipitazioni annue ammontano a 617 mm;
- ad Atessa la temperatura media annua è di 12,7°C*;* la temperatura media mensile oscilla tra 5,5°C (gennaio e febbraio) e 23°C di agosto; la temperatura minima è di -4°C (febbraio) e la massima di 37°C (luglio), le precipitazioni annue sono di circa 780 mm;
- a Bomba la temperatura media annua è di 12,4°C; la temperatura media mensile oscilla tra 5,5°C (gennaio e febbraio) e 23°C di agosto; la temperatura minima assoluta si registra a febbraio -4°C mentre quella massima a luglio con 37°C; le precipitazioni medie annue sono di 965,8 mm;
- a Tornareccio la temperatura media annua è di 12,3°C; la temperatura media mensile oscilla tra 4,5° C di gennaio e febbraio e 22°C di agosto; la temperatura minima assoluta è di -5 °C (febbraio) e quella massima di 36°C (luglio); le precipitazioni medie annue sono di circa 617 mm;
- nell'area circostante il Lago Nero, la temperatura media annua è di circa 11,5 °C: il mese più freddo è gennaio con la temperatura media compresa tra 3 e 4 °C; i mesi più caldi sono luglio e agosto con 21 °C; il regime pluviometrico presenta un valore massimo principale che si registra nel mese di novembre (99 mm) e un massimo secondario in aprile (78,2 mm), dopo si ha una progressiva diminuzione fino a luglio con un minimo di 45,6 mm.

L'insieme dei dati riportati consente di affermare che nel territorio in esame:

- la temperatura media annuale oscilla tra 11,5°C e 13.4°C;
- la temperatura media minima durante l'anno va da circa 3°C a 5,5°C;
- la massima escursione termica annua è di 42°C, essendo compresa tra -5°C a + 37°C;
- le precipitazioni annue sono comprese tra 617 e 965,8 mm;
- in tutti i casi, l'andamento delle precipitazioni è tipico del regime mediterraneo con i valori massimi collocati attorno al tardo autunno, un massimo secondario a inizio primavera e valori minimi durante la stagione estiva.

In conclusione, in accordo con Pellegrini *et al.* (2014, 2018), si può ammettere che il clima locale presenta le seguenti caratteristiche principali: estati non troppo calde con precipitazioni ridotte, un discreto surplus idrico tra settembre e aprile e un periodo freddo ridotto ai mesi di gennaio e febbraio. Tuttavia a causa del non trascurabile gradiente altitudinale, del particolare orientamento dei versanti e d'altri fattori topografici di dettaglio, l'andamento delle temperature e precipitazioni all'interno dell'area SIC/ZSC e dei suoi comuni è soggetto a oscillazioni di una certa rilevanza. Per questi motivi e in base ai valori termopluviometrici osservati, sono state proposte varie classificazioni climatiche.

In base al modello di classificazione di Köppen & Geiger (1954) il clima dell'area basale rientra nel tipo caldo-umido temperato senza stagione secca definito "Cfa" e caratterizzato dalla temperatura media del mese più caldo che supera 22 °C. Le aree poste ad altitudine maggiore hanno un clima più fresco che rientra nel tipo "Cfb", con la temperatura media della stagione estiva inferiore a 22°C.

Ad avviso di Conti & Pirone (1992) l'area in cui si trova il bosco di Vallaspra rientra nella subregione mediterranea di transizione caratterizzata da un periodo secco di durata media inferiore a 2 mesi. Tenendo conto del modello di classificazione climatica di Rivas Martinez (1996), l'area rientra nella Regione Biogegografica Mediterranea caratterizzata da una aridità estiva e precipitazioni concentrate nel periodo tardo-autunnale. I principali termotipi che in essa sono individuabili sono il Mesomediterraneo e il Termomediterraneo mente gli ombrotipi sono il secco e umido/ subumido.

Ad avviso di Pellegrini *et al.* (2014; 2018) l'aera SIC/ZSC è inserita nel bioclima mesotemperato subumido. Secondo Gallucci (2002) l'area del Monte Pallano rientra nella regione climatica temperata e all'orizzonte "collinare superiore (submontano)".

Aspetti vegetazionali e floristici

L'aspetto attuale del paesaggio vegetale, la composizione floristica e le particolarità fitogeografiche dell'ambito di studio sono la conseguenza dell'influsso combinato delle sue peculiarità geografiche, delle sue vicende storico-geologiche, dell'andamento climatico

e della pressione antropica attuale e del passato. Nel complesso l'azione sinergica di tali fattori ha portato alla formazione di habitat molto diversi in cui si sono sviluppate forme di vita vegetale e animale caratterizzate da entità rare e di grande interesse naturalistico.

Per quanto riguarda la pressione antropica, la presenza dell'uomo nell'area è documentata dal Paleolitico (circa 18000-20000 anni fa), come testimoniano i rinvenimenti di selci nelle vicinanze del Monte Pallano. Tuttavia nelle varie zone del SIC/ZSC e dei suoi territori limitrofi, nel corso dei secoli, la presenza umana non è stata sempre continua (Monte Pallano home page).

Nel complesso si può dire che sino ad alcuni decenni fa, in gran parte dell'ambito di studio la pressione antropica si è esercitata con pratiche agro-pastorali che hanno portato alla formazione di molti terreni aperti. Nelle aree incolte e inutilizzate per l'agricoltura e la pastorizia si sono conservate varie tipologie forestali e/o si sono sviluppate formazioni vegetali varie compatibili con le particolari condizioni ecologico-ambientali dei luoghi.

In tempi recenti il rapporto dell'uomo con il territorio in esame e i suoi dintorni è notevolmente cambiato. Le pratiche agro-pastorali tradizionali del passato sono state abbandonate e in varie zone vicine al sito SIC / ZSC di Monte Pallano si osservano: forme di agricoltura intensiva, centri produttivi artigianali e industriali, nuovi insediamenti civili e infrastrutture stradali. A causa di ciò la superficie occupata dai terreni aperti si è ridotta, mentre su quelli abbandonati si sono sviluppate formazioni vegetali arbustive varie ed è ripreso il processo di riforestazione.

In questo periodo l'area SIC/ZSC e i suoi territori limitrofi si presentano come un interessante e complesso mosaico in cui sono presenti formazioni vegetali di diverse caratteristiche. Tenendo conto delle ricerche di Conti & Pirone (1992), Pirone (1995), Ciaschetti *et al.* (2004), Gallucci (2002) e Pellegrini *et al.* (2014, 2018) esse possono essere così riassunte:

- una lecceta alla cui composizione oltre al leccio (*Quercus ilex*) concorrono altre sclerofille sempreverdi poco comuni in Abruzzo: *Arbutus unedo*, *Pistacia lentiscus*, *Phillyrea latifolia*, *Viburnum tinus*, *Smilax aspera* e *Laurus nobilis*.
- una lecceta mista illirico-mediterranea con sclerofille ed essenze arboree caducifoglie tra cui prevalgono l'orniello (*Fraxinus ornus*) e la roverella (*Quercus pubescens*);
- formazioni arbustive presenti nei terreni abbandonati alla cui composizione generalmente concorrono *Viburnum tinus, Pistacia lentiscus, Phyllirea latifolia*, *Paliurus spina-christi*, etc.
- boschi di caducifoglie termofile presenti a quote inferiori 800/900 m s.l.m. e composte dalla roverella (*Quercus pubescens*), il cerro (*Quercus cerris*, l'orniello (*Fraxinus ornus*), il carpino orientale (*Carpinus orientalis*), il biancospino (*Crataegus monogyna*), la berretta da prete (*Euonymus europaeus*), la marruca (*Paliurus spina-christi*), etc.
- bosco misto di caducifoglie mesofile posto sopra 900 metri di quota s.l.m. ed essenzialmente composto da *Tilia* spp., *Acer pseudoplatanus*, *Acer platanoides*, *A. opalus* subsp. *obtusatum*, *Carpinus betulus*, *Quercus cerris* e *Fagus sylvatica*;
- bosco igrofilo presente in una depressione di versante con *Fraxinus oxycarpa*, *Ulmus minor*, *Carex divulsa*, *C. pendula*, *C. remota*, *Chamaeiris foetidissima*, *Ranunculus lanuginosus*, *Rumex sanguineus*, *Serratula tinctoria*, etc.;
- garighe mediterranee con *Aegonychon purpurocaeruleum*, *Ampelodesmos mauritanicus, Brachypodium rupestre*, *Carex flacca*, *Cistus* sp.pl., *Osyris alba, Pistacia lentiscus,* etc.
- varie tipologie di prati-pascolo secondari alla cui composizione generalmente concorrono *Brachipodium rupestre*, *Bromus erectus*, *Phleum hirsutum* subsp. *ambiguum*, *Festuca circummediterranea*, *Lomelosia crenata subsp. pseudisetensis, Thymus longicaulis*, *Micromeria graeca*, *Lotus creticus*, *Helianthemum oelandicum* subsp. *italicum, Elymus repens, Rumex crispus, Dasypyrum villosum*, *Ranunculus bulbosus*, *Centaurea solstitialis*, etc.

Un'importante particolarità del luogo è la presenza in aree molto prossime di una formazione forestale tipicamente mediterranea (la lecceta) e una faggeta ossia una formazione vegetale tipica di territori più freschi che nel territorio in esame attecchisce all'altitudine di circa 800 metri e si può considerare azonale.

Ad avviso di Pellegrini *et al*. (2014; 2018), una particolare menzione la meritano due particolari ambiti presenti nei dintorni dell'area. Il primo di essi analizzato da Conti & Pirone (1992), è denominato la cerreta di Vallaspra o bosco di San Pasquale ed è posto nel territorio comunale di Atessa a poca distanza dai confini del SIC/ZSC. Alla sua formazione oltre al cerro concorrono *Acer campestre*, *A. opalus* subsp. *obtusatum*, *Carpinus betulus*, *Fraxinus angustifolia* subsp. *oxycarpa*, *F. ornus*, *Ilex aquifolium*, *Ruscus aculeatus*, *Sorbus domestica*, *S. torminalis*, *Tilia plathyphyllo*s, *Carex olbiensis, C. remota*, *C. sylvatica*, *Chamaeiris foetidissima*, *C. lorea*, *Daphne laureola*, *Drymochloa drymeja* subsp. *exaltata*, *Lathyrus pannonicus* subsp. *varius*, *Lilium bulbiferum* subsp. *croceum* ed altro.

Il secondo ambito è rappresentato dai calanchi di Atessa-Tornareccio che è stato analizzato nelle sue componenti vegetazionali da Pirone (1995). Alcune specie più caratteristiche e importanti del suo territorio sono le seguenti: *Anacyclus tomentosus*, *Anemone hortensis*, *Artemisia caerulescens* subsp. *caerulescens*, *Arundo*

plinii, *Atriplex prostrata, Beta vulgaris* subsp. *maritima*, *Bupleurum tenuissimum*, *Cardopatium corymbosum*, *Catananche lutea*, *Cynara cardunculus* subsp. *cardunculus*, *Hedysarum coronarium*, *Hordeum maritimum*, *Parapholis cylindrica*, *Romulea ramiflora* subsp. *ramiflora*, *Spartium junceum*, *Tamarix africana*, etc.

Per quanto riguarda la consistenza del patrimonio floristico, le ricerche di Conti *et al*. (2011; 2015; 2017), Marco Paolucci (Monte Pallano Home page) e Pellegrini *et al*. (2014; 2018) eseguite nell'area del SIC/ZSC e in quelle dei territori strettamente limitrofi portano al conteggio complessivo di circa 1250 taxa ripartiti in 110 famiglie. Le entità presenti rappresentano oltre un terzo dell'intera flora regionale che nel complesso annovera oltre 3360 taxa (Bartolucci *et al*., 2018; Pirone, 2020).

MATERIALI E METODI

Il territorio d'indagine comprende tutta l'aera SIC/ZSC e le aree limitrofe, quali la cerreta di Vallaspra, i calanchi di Atessa-Tornareccio, la lecceta di Isca d'Archi e altre zone ricadenti nei comuni di Archi, Atessa, Bomba, Colledimezzo e Tornareccio.

L'elenco floristico è stato realizzato tenendo conto: delle ricerche sul campo degli autori e dei dati ricavati dalle consultazioni bibliografiche. Esso comprende le specie, le sottospecie e gli ibridi mentre non sono state prese in considerazione le varietà cromatiche e morfologiche.

Le ricerche nell'area sono iniziate circa 30 anni fa con l'annotazione di tutte le specie che di volta in volta si rinvenivano e sono continuate sino al 2021 con frequenze più o meno settimanali dal mese di marzo a quello di settembre.

Per la nomenclatura delle orchidee si sono seguite le indicazioni di GIROS (2016) con le seguenti eccezioni:

- sono state ricondotte a *Ophrys sphegodes* subsp. *sphegodes* tutte le segnalazioni di *O. aranifera s.l.* e di *O. sphegodes* subsp. *classica*, due taxa che per Hertel & Presser (2006) rientrano nella variabilità di *O. sphegodes* e che per De Simoni & Biagioli (GIROS 2016), sono da approfondire ulteriormente;
- sono state ricondotte a *Ophrys bertolonii* tutte le segnalazioni di *O. romolinii* Soca.

Per quanto riguarda la nomenclatura dei taxa appartenenti ad altre famiglie è stata seguita quella proposta da Bartolucci et al. (2018).

Alla luce delle recenti revisioni tassonomiche, dalla flora abruzzese vanno escluse le seguenti entità che in passato erano state segnalate per il territorio in esame:

- *Ophrys fusca* Link subsp. *fusca* le cui piante presenti nell'area sono state ricondotte alle sottospecie *funerea* e *lucana;*
- *Ophrys holosericea* (Burm. f.) Greuter subsp. *holosericea*, a sua volta ricondotta a *O. holosericea* subsp. *appennina*, *O. holosericea* subsp. *dinarica*, *O. holosericea* subsp. *gracilis* e *O. holosericea* subsp. *pinguis*.

Per l'assegnazione dei tipi corologici si è tenuto conto di quanto riportato in Pignatti (2017) e Pezzetta (2011). Al corotipo Appennino-Balcanico sono stati assegnati i taxa presenti esclusivamente nel territorio delimitato dai seguenti confini fisici (Pezzetta, 2010): 1) per la Penisola Italiana, le isole e l'arco appenninico dalla Liguria all'Aspromonte; 2) per la Penisola Balcanica, Creta, le isole dell'Egeo e il territorio continentale posto a sud dell'asse fluviale che va dalle sorgenti della Sava alle foci del Danubio e dal Mar Nero all'Adriatico-Ionio.

Accanto ad ogni taxon sono riportati: il tipo corologico, gli autori che l'hanno segnalato, tutte le località in cui è stata registrata la presenza e le eventuali osservazioni sul rango tassonomico. I toponimi indicati nel testo sono reperibili nella cartografia IGM riguardante la zona. Tutti i taxa sono stati osservati dagli autori del presente saggio.

RISULTATI E DISCUSSIONE

Elenco floristico

1. *Anacamptis morio* (L.) R.M. Bateman, Pridgeon & M.W. Chase - Europeo-Caucasico. (Monte Pallano Home page; Pezzetta, 2016). Archi (Contrada Fara, Fontemaggiore, Fosso della Fonte dei Santi), Atessa (Coste Pertelle, Fontecampana, Vallaspra), Bomba (La Crocetta, Monte Pallano zona antenne, Sambuceto, San Mauro Vecchio), Colledimezzo (c/o campeggio Il Soffio, Colle Butino, Contrada Maccarone), Tornareccio (Colle Case, Colle Pelato, I Piani, La Torretta, Lago Nero).
2. *Anacamptis papilionacea* (L.) R.M. Bateman, Pridgeon & M.W. Chase - Eurimediterraneo. (Monte Pallano Home page; Pezzetta, 2016). Archi (Fosso della Fonte dei Santi), Colledimezzo (Contrada Maccarone).
3. *Anacamptis pyramidalis* (L.) Rich. – Eurimediterraneo. (Monte Pallano Home page; Pellegrini *et al*., 2014; Pezzetta, 2016; Pellegrini *et al*., 2018). Archi (Contrada Grotte, Fosso della Fonte dei Santi, La Serra, Le Coste, Piano Carrozza), Atessa (Fontecampana, Fonte Rio Falco, Vallaspra), Bomba (Il Convento, La Crocetta, Monte Pallano zona antenne, Sambuceto), Colledimezzo (Cirone, Colle Butino, Contrada Maccarone), Tornareccio (Colle Case, Fondo d'Izzo, I Piani, Lago Nero, San Giovanni).
4. *Cephalanthera damasonium* (Mill.) Druce – Eurimediterraneo. (Monte Pallano Home page; Conti & Pirone, 1992; Pellegrini *et al*., 2014;

Pezzetta, 2016; Pellegrini *et al.*, 2018). Archi (Contrada Fara, Fosso della Fonte dei Santi, La Sorgente, Monte Rione), Atessa (Coste di Serra, Fontecampana, Vallaspra), Bomba (La Crocetta, Monte Pallano zona antenne, Sambuceto, San Mauro Vecchio), Colledimezzo (Colle Butino), Tornareccio (Fondo d'Izzo, I Piani, Lago Nero).

5. *Cephalanthera longifolia* (L.) Fritsch – Eurasiatico. (Monte Pallano Home page; Pellegrini *et al.*, 2014; Pezzetta, 2016; Pellegrini *et al.*, 2018). Archi (Monte Rione), Bomba (Sambuceto), Atessa (Fonecampana, Portelle, Vallaspra), Tornareccio (La Torretta, Lago Nero).
6. *Cephalanthera rubra* (L.) Rich. – Eurasiatico. (Monte Pallano Home page; Pellegrini *et al.*, 2014; Pezzetta, 2016; Pellegrini *et al.*, 2018). Archi (Fontemaggiore, Monte Rione), Atessa (Fontecampana), Bomba (La Crocetta, San Mauro Vecchio), Colledimezzo (Colle Butino, Contrada Maccarone), Tornareccio (Bosco Sant'Onofrio, Lago Nero).
7. *Dactylorhiza maculata* (L.) Soó subsp. *fuchsii* (Druce) Hyl. – Eurasiatico. Tornareccio (Lago Nero).
8. *Dactylorhiza maculata* subsp. *saccifera* (Brongn.) Diklić – Paleotemperato. (Monte Pallano Home page; Pezzetta, 2016). Atessa, Bomba (San Mauro Vecchio), Colledimezzo (Contrada Maccarone), Tornareccio (Fondo d'Izzo, Fonte Benedetti, Lago Nero).
9. *Epipactis atrorubens* (Hoffm.) Besser – Europeo. Atessa (Vallaspra).
10. *Epipactis helleborine* (L.) Crantz subsp. *helleborine*– Paleotemperato. (Monte Pallano Home page; Pezzetta, 2016). Archi (Fontemaggiore, Monte Rione), Atessa (Fontecampana), Bomba (La Crocetta, Sambuceto), Colledimezzo (Colle Butino), Tornareccio (Faggeta, Il Lago).
11. *Epipactis microphylla* (Ehrh.) Sw. – Europeo-Caucasico. (Monte Pallano Home page; Pezzetta, 2016). Archi (Fosso della Fonte dei Santi), Atessa (Fontecampana), Bomba, Colledimezzo (Colle Butino), Tornareccio (Faggeta, Fondo d'Izzo).
12. *Epipactis muelleri* Godfery – Centroeuropeo. (Monte Pallano Home page). Archi (Monte Torretta), Atessa (Fontecampana).
13. *Gymnadenia conopsea* (L.) R. Br. in W.T. Aiton – Eurasiatico. (Pirone, 1995; Monte Pallano Home page; Pezzetta, 2016). Atessa (Fontecampana), Bomba (La Crocetta, Monte Pallano zona antenne, Sambuceto), Tornareccio (I Piani, Lago Nero).
14. *Himantoglossum adriaticum* H. Baumann – Eurimediterraneo. (Monte Pallano Home page; Pellegrini *et al.*, 2014, Pezzetta, 2016; Pellegrini *et al.*, 2018). Atessa (Vallaspra), Bomba (Monte Pallano zona antenne), Tornareccio (Lago Nero, San Mauro Vecchio).
15. *Limodorum abortivum* (L.) Sw. – Eurimediterraneo. (Monte Pallano Home page; Pezzetta, 2016). Archi (Fosso della Fonte dei Santi), Atessa (Fontecampana, Vallaspra), Bomba (Monte Pallano zona antenne, Sambuceto), Colledimezzo (Colle Butino), Tornareccio (Faggeta, I Piani, Lago Nero, San Giovanni).
16. *Listera ovata* (L.) R. Br. – Eurasiatico. (Monte Pallano Home page; Pellegrini *et al.*, 2014, Pezzetta, 2016; Pellegrini *et al.*, 2018). Atessa (Vallaspra), Tornareccio (Lago Nero).
17. *Neotinea tridentata* (Scop.) R.M. Bateman, Pridgeon & M.W. Chase – Eurimediterraneo. (Pezzetta, 2016). Atessa (Fontecampana), Tornareccio (La Torretta).
18. *Neottia nidus-avis* (L.) Rich. – Eurasiatico. (Monte Pallano Home page; Pezzetta, 2016). Archi (Fosso della Fonte dei Santi, Monte Rione), Atessa (Fontecampana, Vallaspra), Bomba (Sambuceto, San Mauro Vecchio), Colledimezzo (Colle Butino), Tornareccio (Faggeta, Fondo D'Izzo, Lago Nero).
19. *Ophrys apifera* Huds. – Eurimediterraneo. (Monte Pallano Home page; Pellegrini *et al.*, 2014; Pezzetta, 2016; Pellegrini *et al.*, 2018). Archi (Fara, Fosso della Fonte dei Santi), Atessa (Fontecampana, Fonte Rio Falco, Vallaspra), Bomba (Monte Pallano zona antenne, Sambuceto), Colledimezzo (Colle Butino, Contrada Maccarone, Ponte Cefalone), Tornareccio (I Piani, Lago Nero).
20. *Ophrys argolica* subsp. *crabronifera* Faurh. – Endemico. (Monte Pallano Home page). Bomba (Vallecupa), Tornareccio (Fondo d'Izzo).
21. *Ophrys bertolonii* subsp. *bertolonii* Moretti - Appennino-Balcanico. (Monte Pallano Home page; Pellegrini *et al.*, 2014, Pezzetta, 2016; Pellegrini *et al.*, 2018). Archi (Fosso della Fonte dei Santi), Atessa (Fontecampana, Fonte Rio Falco, Vallaspra), Bomba (Monte Pallano zona antenne, Sambuceto), Colledimezzo (Colle Butino, Tornareccio (Colle Pizzuto, La Torretta, Lago Nero, I Piani).
22. *Ophrys bombyliflora* Link – Stenomediterraneo. (Monte Pallano Home page; Pellegrini *et al.*, 2014; Pezzetta, 2016; Pellegrini *et al.*, 2018). Atessa (Coste di Serra, Fonte Rio Falco).
23. *Ophrys fusca* subsp. *funerea* Link – Mediterraneo-Atlantico. (Monte Pallano Home page). Bomba (Monte Pallano zona antenne), Tornareccio (Colle Pizzuto, I Piani).
24. *Ophrys fusca* subsp. *lucana* (P. Delforge, Devillers-Tersch. & Devillers) Kreutz – Endemico. Tornareccio (I Piani).
25. *Ophrys holosericea* (Burm. f.) Greuter subsp. *appennina (*Romolini & Soca) Kreutz – Endemico. Tornareccio (Coste dell'Oppio, I Piani).

26. *Ophrys holosericea* (Burm. f.) Greuter subsp. *dinarica* (Kranjcev & P. Delforge) – Appennino-Balcanico. (Pezzetta, 2016). Atessa (Fontecampana).
27. *Ophrys holosericea* subsp. *gracilis* (Büel, O. Danesch & E. Danesch) Büel, O. Danesch & E. Danesch – Endemico. Atessa (Fontecampana).
28. *Ophrys holosericea* (Burm. f.) Greuter subsp. *pinguis* (Romolini & Soca) Kreutz – Endemico. Bomba (Valle Cupa).
29. *Ophrys incubacea* Bianca subsp. *incubacea* – Stenomediterraneo. (Monte Pallano Home page; Pezzetta, 2016). (Fosso della Fonte dei Santi), Colledimezzo (Cirone).
30. *Ophrys insectifera* L. – Europeo. (Monte Pallano Home page; Pellegrini *et al.*, 2014; Pezzetta, 2016; Pellegrini *et al.*, 2018). Archi (Fontemaggiore, Pianella), Atessa (Bivio Strada Piano Ciccarelli, Vallaspra).
31. *Ophrys lutea* subsp. *lutea* Cav. – Stenomediterraneo. (Monte Pallano Home page; Pellegrini *et al.*, 2014; Pezzetta, 2016). Atessa (Vallaspra SP 216).
32. *Ophrys molisana* Delforge – Endemico. Archi, Atessa (Fontecampana), Bomba (Valle Cupa), Colledimezzo (Colle Butino), Tornareccio (I Piani). Osservazioni. Il taxon, di dubbio valore tassonomico, è *stato* descritto da Delforge (2015), si può inserire nel gruppo di *Ophrys sphegodes* e non è riportato in GIROS (2016). Tenendo conto del suo periodo di fioritura più tardivo rispetto ad altre specie simili, delle sue particolari caratteristiche morfologiche e in accordo con Soca (2017) e Bartolucci *et al.* (2018) che ammettono la sua presenza in Abruzzo ed altre regioni, lo si considera una buona specie che si segnala nel territorio d'indagine.
33. *Ophrys passionis* subsp. *passionis* Sennen ex Devillers-Tersch. & Devillers (sin. *O. garganica* O. Danesch & E. Danesch) – Mediterraneo-Occidentale. (Monte Pallano Home page; Pellegrini *et al.*, 2014, Pezzetta, 2016, Pellegrini *et al.*, 2018). Bomba (Accorvo), Colledimezzo (Cirone).
34. *Ophrys promontorii* O. Danesch & E. Danesch – Endemico. (Monte Pallano Home page; Pellegrini *et al.*, 2014, Pezzetta, 2016; Pellegrini *et al.*, 2018). Archi (Fosso della Fonte dei Santi), Atessa (Vallaspra), Bomba (Monte Pallano zona antenne), Colledimezzo (Colle Butino), Tornareccio (Fondo d'Izzo, I Piani, Lago Nero, La Torretta).
35. *Ophrys sphegodes* subsp. *sphegodes* Mill. – Eurimediterraneo. (Monte Pallano Home page; Pezzetta, 2016). Archi (Fosso della Fonte dei Santi, La Serra, Le Coste, Piano Carrozza), Atessa (Fontecampana, Vallaspra), Bomba (Il Convento, La Crocetta, Monte Pallano zona antenne, Sambuceto), Colledimezzo (Cirone, Colle Butino, Contrada Maccarone), Tornareccio (Colle Case. Fondo d'Izzo, I Piani, Lago Nero).
36. *Orchis anthropophora* (L.) All. – Mediterraneo-Atlantico. (Monte Pallano Home page; Pezzetta, 2016). Archi (Fonte Maggiore Monte Rione), Atessa (Fontecampana, Fonte Rio Falco, Vallaspra), Bomba (Monte Pallano zona antenne, Portelle, Sambuceto), Colledimezzo (Colle Butino), Tornareccio (Fondo d'Izzo, I Piani, Coste del Lago Nero).
37. *Orchis italica* Poir. – Stenomediterraneo. (Monte Pallano Home page; Pellegrini *et al.*, 2014; Pellegrini *et al.*, 2018). Archi (Contrada Fara, Fosso della Fonte dei Santi, La Sorgente), Atessa (Fontecampana, Vallaspra), Bomba (La Crocetta, San Mauro Vecchio, Monte Pallano zona antenne, Sambuceto), Colledimezzo (Colle Butino), Tornareccio (Colle Case, Lago Nero, Piani di Pallano).
38. *Orchis militaris* L. – Eurasiatico. Bomba (Sambuceto).
39. *Orchis pauciflora* Ten. – Stenomediterraneo. (Monte Pallano Home page; Pezzetta, 2016). Atessa (Vallaspra), Tornareccio (Coste del Lago Nero, San Giovanni).
40. *Orchis provincialis* Balb. Ex Lam. – Stenomediterraneo. (Monte Pallano Home page; Pellegrini *et al.*, 2014; Pezzetta, 2016; Pellegrini *et al.*, 2018). R. Atessa (Vallaspra SP 216).
41. *Orchis purpurea* Huds. – Eurasiatico. (Monte Pallano Home page; Pellegrini *et al.*, 2014; Pezzetta, 2016; Pellegrini *et al.*, 2018). Archi (Fontemaggiore, Fosso della Fonte dei Santi, Monte Rione), Atessa (Coste Pertelle, Fontecampana, Vallaspra), Bomba (La Crocetta, Portelle, San Mauro Vecchio, Sambuceto), Colledimezzo (Colle Butino, Contrada Maccarone), Tornareccio (Colle Case, Lago Nero, Piani di Pallano, San Giovanni).
42. *Orchis simia* Lam. – Eurimediterraneo. Bomba (Sambuceto).
43. *Platanthera bifolia* (L.) Rchb. subsp. *bifolia* – Paleotemperato. (Monte Pallano Home page; Pezzetta, 2016). Archi, Bomba.
44. *Platanthera chloranha* (Custer) Rchb. – Eurosiberiano. Bomba (Sambuceto).
45. *Serapias parviflora* Parl. – Stenomediterraneo. (Monte Pallano Home page; Pellegrini *et al.*, 2014; Pezzetta, 2016; Pellegrini *et al.*, 2018). Archi (Fosso della Fonte dei Santi), Bomba (Crocetta, Monte Pallano zona antenne), Atessa (Vallaspra), Colledimezzo (Colle Butino, Colle Rinello c/o superstrada, Contrada Maccarone), Tornareccio (calanchi, Lago Nero).
46. *Serapias vomeracea* (Burm.f.) Briq. subsp. *vomeracea* – Eurimediterraneo. (Monte Pallano Home page; Pezzetta, 2016). Archi, Atessa, Bomba, Colledimezzo (Contrada Maccarone), Tornareccio (San Giovanni).
47. *Spiranthes spiralis* (L.) Chevall. – Europeo-Caucasico. (Monte Pallano Home page; Pezzetta, 2016). Archi (Fosso della Fonte dei Santi), Colledimezzo (Colle Butino), Tornareccio (Piani di Pallano).

Tab. 1: Generi e specie delle Orchidaceae dell'area di studio.
Tab. 1: Rodovi in število vrst iz družine Orchidaceae na obravnavanem območju.

Genere	**Numero taxa**	**Genere**	**Numero taxa**
Anacamptis	3	*Neotinea*	1
Cephalanthera	3	*Neottia*	1
Dactylorhiza	2	*Ophrys*	17
Epipactis	4	*Orchis*	7
Gymnadenia	1	*Platanthera*	2
Himantoglossum	1	*Serapias*	2
Limodorum	1	*Spiranthes*	1
Listera	1		

L'elenco floristico è costituito da 47 taxa specifici e infraspecifici che facendo riferimento a Pezzetta (2018) rappresentano il 48,4% delle Orchidaceae presenti in Abruzzo e il 18,3% di quelle nazionali.

Allo stato attuale delle conoscenze l'ambito di studio rappresenta la terza area provinciale più ricca di orchidacee dopo il versante orientale della Majella e l'abetina di Rosello.

I taxa nuovi non riportati, nel sito Monte Pallano Home page, in Pezzetta (2016) e in altri saggi bibliografici sono i seguenti: Dactylorhiza maculata subsp. fuchsii, Epipactis atrorubens, Ophrys fusca subsp. lucana, O. Ophrys holosericea subsp. appennina, O. holosericea subsp. gracilis, O. holosericea subsp. pinguis, O. molisana, Orchis militaris, O. simia e Platanhera chlorantha.

Dalla Tabella 1 uno emerge che le varie entità si ripartiscono in 15 generi tra cui il più rappresentato è il genere Ophrys con 17 taxa. Seguono i generi:Orchis (7 taxa),Epipactis (5 taxa), Anacamptis e Cephalanthera (3 taxa),Dactylorhiza, Platantherae Serapias (2 taxa) e infine tutti gli altri con un taxon ciascuno.

Dalla Tabella 2 si può osservare che lo spettro corologico è costituito da 12 diversi corotipi ripartiti in 5 contingenti geografici tra cui prevale il contingente Mediterraneo (18 taxa). Esso è seguito dai contingenti Eurasiatico (15 taxa), Endemico (7 taxa), Europeo (4 taxa) ed Atlantico (2 taxa).

Tra i vari corotipi prevale l'Eurimediterraneo (10 taxa). Esso è seguito dai corotipi Eurasiatico (8 taxa), Endemico e Stenomediterreaneo (7 taxa), Europeo-Caucasico e Paleotemperato (3 taxa), Europeo s. s., Appennino-Balcanico e Mediterraneo-Atlantico (2 taxa) e tutti gli altri con un taxon ciascuno.

In accordo con Poldini (1991), tenendo conto dei corotipi di appartenenza dei taxa considerati, sono stati fatti tre raggruppamenti definiti macrotermici, mesotermici e microtermici che consentono di evidenziare le preferenze climatiche dei taxa stessi.

Il raggruppamento macrotermico comprende i contingenti Mediterraneo e Endemico che è rappresentato da 7 taxa del genere *Ophrys*. Questa categoria nell'area in esame è la più rappresentata con 25 taxa, a conferma che una sua gran parte è caratterizzata da un clima temperato caldo, zone soleggiate e riparate dalle correnti fredde che facilitano l'attecchimento delle entità termofile.

Il raggruppamento mesotermico comprende i corotipi Appennino-Balcanico, Eurasiatico, Europeo, Centro-Europeo, Mediterraneo-Atlantico, Europeo-Caucasico e Pa-

Tab. 2: Corotipi delle Orchidaceae rinvenute nell'area di studio.
Tab 2: Horotipi kukavičevk, potrjenih na obravnavanem območju.

Contingenti Geografici e Corotipi (1)	**Numero taxa**	**%**
Endemico	**7**	**14,89**
Endemico	7	
Mediterraneo	**18**	**38,3**
Eurimediterraneo	10	
Stenomediterraneo	7	
Mediterraneo-Occidentale	1	
Eurasiatico	**15**	**31,91**
Eurasiatico s. s.	8	
Europeo-Caucasico	3	
Paleotemperato	3	
Eurosiberiano	1	
Europeo	**5**	**10,64**
Europeo s. s.	2	
Appennino-Balcanico	2	
Centro-Europeo	1	
Atlantico	**2**	**4,26**
Mediterraneo-Atlantico	2	
Totale	**47**	**100**

leotemperato. Questa categoria segue il raggruppamento macrotermico con 21 taxa e dimostra che nell'ambito di studio sono presenti aree caratterizzate da un clima più fresco in cui attecchiscono piante mesofile.

Il raggruppamento microtermico comprende il corotipo Eurosiberiano e nel complesso è rappresentato da un solo taxon, a dimostrazione che nell'area esistono particolari nicchie in cui attecchiscono entità tipiche di ambiti molto freschi.

La presenza contemporanea di taxa appartenenti a 3 raggruppamenti diversi di corotipi conferma che il territorio in esame è un ambito di transizione biogeografica caratterizzato da varie tipologie ambientali e climatiche che consentono l'attecchimento di entità vegetali con esigenze termiche ed ecologiche molto diversificate.

CONCLUSIONI

Il considerevole numero di taxa di orchidacee rilevato conferma l'importanza naturalistica del territorio esaminato, avvalora la scelta di istituirvi un ambito di tutela e si può considerare un indicatore della sua grande qualità ambientale. Tali piante attecchiscono su terreni oligotrofici e stabili che non sono alterati da dissodamenti, concimazioni e largo uso di diserbanti e insetticidi che alterando le caratteristiche fisico-chimiche dell'aria, dell'acqua e del suolo, possono essere la causa dell'estinzione dei funghi micorrizici e degli insetti pronubi da cui dipende la loro vita.

Nel loro complesso i taxa considerati sono stati osservati in 40 località distinte appartenenti a 5 Comuni. Tali importanti segnalazioni arricchiscono la geografia floristica regionale e provinciale con nuove aree di presenza.

All'interno sito SIC/ZSC in esame, il maggior numero di entità è stato osservato nei dintorni del Lago Nero (Comune di Tornareccio, 21 taxa), Fonte Campana (Comune di Atessa, 20 taxa), Colle Butino (Comune di Colledimezzo, 18 taxa) e al Fosso Fonte dei Santi (Comune di Atessa 16 taxa). In tali ambiti le efficaci misure protezionistiche in atto assicurano la loro conservazione. All'esterno dell'area si registra un'elevata presenza nei dintorni di Vallaspra (Comune di Atessa, 21 taxa) in cui ora non sono predisposte efficaci misure protezionistiche. Va comunque evidenziato che in tutti i casi considerati, le trasformazioni vegetazionali in atto possono portare a una modifica della consistenza numerica delle orchidacee presenti. Infatti all'abbandono di certe forme di attività agro-pastorali tradizionali e all'espansione delle aree forestali, seguono: la scomparsa delle entità tipiche dei prati-pascolo e una maggiore diffusione di quelle degli ambiti boschivi e cespugliosi. Di conseguenza per un'adeguata tutela di tale famiglia di piante, le misure protezionistiche devono comprendere anche azioni di disturbo finalizzate ad ostacolare l'evoluzione della vegetazione e alla conservazione degli habitat presenti.

KUKAVIČEVKE OBMOČJA, POMEMBNEGA ZA SKUPNOST "MONTE PALLANO E LECCETA D'ISCA D'ARCHI" IN SOSEDNJIH OBMOČIJ

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POVZETEK

Območje SIC/ZSC "Monte Pallano e Lecceta d'Isca d'Archi" se nahaja v provinci Chieti v Abrucih. Pokriva površino 3270 ha, je zelo raznolik in premore izjemno floristično pestrost s približno 1250 ugotovljenimi taksoni višjih rastlin. Avtorji na podlagi pregleda dosedanjih raziskav v pričujočem delu nov seznam vseh kukavičevk in horološko analizo, ki kaže na prevladovanje sredozemskih florističnih elementov. V florističnem seznamu navajajo 47 taksonov, ločenih na vrste in podvrste. Med njimi je tudi 7 endemičnih vrst, ki dajejo obravnavanemu območju izjemen fitogeografski pomen.

Ključne besede: Monte Pallano, Orchidaceae, Abruci, osrednja Italija, seznam vrst, horološki spekter

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DELO NAŠIH ZAVODOV IN DRUŠTEV

ATTIVITÀ DEI NOSTRI ISTITUTI E SOCIETÀ

ACTIVITIES BY OUR INSTITUTIONS AND ASSOCIATIONS

v vrtincu sprememb

POVEZANOST VODE, ŽIVLJENJA IN PODNEBJA

OKOLJSKI MANIFEST

Težava človekovega čezmernega poseganja v okolje ni posledica neinformiranosti, pač pa prej hotene nevednosti in načrtnega izogibanja ter zanikanja podatkov, ki kažejo na katastrofalne posledice teh posegov. Razmišljanje o nenadni radikalni spremembi življenjskega sloga, ki je potrebna, da bi naše ravnanje postalo bolj okoljsko vzdržno, za marsikoga predstavlja velik stres. Pomenilo bi namreč spremembo dosedanjega načina življenja, iz katerega posamezniki in družba črpamo svoje identitete in smisel. Kljub vsemu danes postaja etični imperativ, da se odrečemo svoji pristranskosti in nepotrebnemu potrošništvu. Planet moramo zavarovati, zato da bi lahko na njem preživeli mi, naši potomci in ves živi svet.

Zavezani znanosti za boljši svet

Nacionalni inštitut za biologijo in Mladi za podnebno pravičnost smo pripravili razpravo o biodiverziteti, vodi in razogličenju v obliki intredisciplinarnega simpozija, ki je potekal 14. in 15. oktobra 2021. Ključna sporočila simpozija, povzeta iz razprav in okroglih miz ponujajo nabor predlogov ter rešitev za izboljšanje odziva na globalne okoljske spremembe. Pozivamo znanstvenike s področij ved o življenju, ekonomije, tehnologije, filozofije in družboslovja, politike in vse ljudi, da dogovorno in odgovorno rešimo kompleksna okoljska vprašanja, ki ogrožajo planet in z njim nas same. Da bi bil zeleni dogovor mogoč, je nujen interdisciplinarni pregled preteklih in sedanjih praks za ustvarjanje inovativne, a realne prihodnosti.

Zemlja, imamo problem

Za podnebne spremembe ne moremo več kriviti zunanjih dejavnikov, smo njihov izvirni del, kot del kompleksnega prilagodljivega sistema planeta Zemlja. Zaradi antropogenih izpustov toplogrednih plinov je danes površje planeta za 1,1 °C toplejše glede na obdobje 1850–1900. Ogrevanje na kopnem je večje od svetovnega povprečja, na Arktiki pa več kot dvakrat višje. Podnebne spremembe prinašajo izrazite spremembe kroženja vode – večje izhlapevanje, intenzivnejše padavine in s tem povezane poplave ter močnejšo sušo v mnogo regijah, pa tudi spremembe vlažnosti, vetrov, snega in ledu ter spremembe obalnih območij in oceanov. V urbanih območjih se nekateri vidiki podnebnih sprememb še bolj izrazijo.

Raznovrstne posledice človekovega delovanja, med katere spadajo podnebne spremembe, se odražajo tudi v biodiverziteti. Hitrost izumiranja ptic, kot primer bolje proučene skupine organizmov, zaradi posledic evolucije naj bi bila ena vrsta v 83 letih, danes pa se je ta hitrost pospešila na eno vrsto v 3–4 letih. Samo na območju Slovenije je v zadnjih 500 letih lokalno izumrlo 10 % sesalcev, 7 % ptic, 4 % rib in 20 % hroščev, za veliko večino organizmov pa teh podatkov sploh ni. Ohranjanje biodiverzitete tako ne sme ostati le zanesenjaško naravovarstvo, pač pa je nuja za preživetje prihodnjih generacij ljudi.

Voda omogoča življenje vseh organizmov na Zemlji – tako vodnih, vključno s tistimi v podzemnih vodah, za katere je Slovenija tudi na globalni ravni vroča točka biodiverzitete, kot kopenskih. Morja in oceani so največji zemeljski ekosistem, ki ima ogromen vpliv na vremenske pojave, predstavlja skladišče ogljikovega dioksida in proizvede polovico kisika na Zemlji, poleg tega je tudi pomemben vir hrane. Reke pa so kot ožilje planeta, ki s pretakanjem vode od gora proti morjem oblikujejo

življenje na kopnem. Pitna voda je kot pravica vsakega celo zapisana v našo ustavo. Slovenci se radi ponašamo z vodnim bogastvom svoje dežele. Večina prebivalcev se, sodeč po nedavnem referendumu o vodah, tudi zaveda pomembnosti vodnih in priobalnih ekosistemov, katerih stanje žal ni tako dobro.

Človekov vpliv se danes zaradi rabe in izrabe vodnih virov, naseljevanja v bližini vodnih površin in na poplavnih ravnicah, izsuševanja mokrišč, kmetijstva in gnojenja ter onesnaževanja čuti na vseh porečjih. Podatki Ministrstva za okolje in prostor kažejo, da je bilo v obdobju 2016–2019 51 % vodnih teles v zmernem, slabem ali zelo slabem ekološkem stanju, kar je zelo slab rezultat. V Sloveniji je predvsem zaradi poseljenosti poplavnih površin degradiranih 50 % poplavnih območij, kar je 10 % več od evropskega povprečja. Na slovenske reke smo namestili več kot 60.000 pregrad in pragov. Na drugi strani je na ravni EU v okviru evropskega zelenega dogovora vključen načrt, da bi 25.000 km rek prosto teklo in se po potrebi tudi razlivalo, saj je ravnanje in ukalupljanje strug rek v betonska korita preživet koncept.

Strategija EU za biodiverziteto predvideva vzpostavitev zaščitenih območij za najmanj 30 % morskih površin do leta 2030. V Sloveniji smo še zelo daleč od te številke, saj morska zavarovana območja – KP Strunjan, KP Debeli rtič in NS Rt Madona ter območja Natura 2000, ki vključujejo tudi del morja – obsegajo le nekaj več kot 3 % slovenskega morja.

Zaradi podnebnih sprememb spremenjene temperaturne in hidrološke razmere še dodatno vplivajo na pestrost in distribucijo vodnih organizmov – od novih mikrobnih patogenov in škodljivih organizmov, do bioinvazije vretenčarskih vrst, predvsem rib. Nekateri organizmi se v spremenjenih okoljih odlično počutijo, na primer cianobakterije v celinskih vodah ob povečani vsebnosti hranil, ali pa tujerodne ribe, raki in polži v še neizkoriščenih ekoloških nišah. Ti lahko močno vplivajo na stanje ekosistemov, večinoma v negativnem smislu. Včasih lahko v te vplive posežemo, jih spremljamo in ovrednotimo in, kot v primeru pojava toksičnih cvetenj cianobakterij v manjših vodnih telesih, morebiti celo zatremo. Do določene mere lahko z umetnim obnavljanjem ekosistemov nadomestimo tudi izginjanje morskih travnikov in koral.

Posledice okoljskih sprememb so pogosto nepovratne in izven našega dosega. Taki sta predvidena rast gladine morja, ki bo močno vplivala na obalna območja, in izgubljanje celokupne biodiverzitete določenih ekosistemov. Poškodovani ekosistemi so zaradi temperaturnih, vodnih in drugih vremenskih šokov še bolj na udaru, kar nas mora skrbeti, saj so organizmi ključni pri blaženju tovrstnih pojavov. To je pomemben razlog, zakaj se mora biodiverziteta ohranjati. Pri preprečevanju globalne rasti gladine in temperature morja so edine možne rešitve že znane: čim širše in hitrejše razogljičenje proizvodnje energije in zmanjševanje njene porabe na način, ki ne bo poglobil krize biodiverzitete.

Že predlagani ukrepi za prilagajanje podnebnim spremembam se odražajo v evropskem zelenem dogovoru. Dogovor utira pot k zakonodaji, ki obravnava podnebno nevtralnost in tudi povečuje odpornost proti že zaznanim ali pričakovanim posledicam podnebnih sprememb s prilagoditveno strategijo EU. EU sveženj »Pripravljeni na 55« se nanaša na cilj zmanjšanja izpustov toplogrednih plinov za najmanj 55 % do leta 2030 ter vsebuje številne zakonodajne spremembe na različnih področjih. Čeprav predlagana evropska zakonodaja predstavlja pomemben korak naprej, je ekonomsko in socialno nezadostna ter le delno v skladu s podnebno znanostjo. Za preprečitev najhujših posledic podnebnih sprememb nam namreč slednja predlaga 65odstotno znižanje toplogrednih plinov do leta 2030 ter doseganje neto brezogljične družbe okoli leta 2040. Dolgoročna podnebna strategija Slovenije do leta 2050, ključni dolgoročni podnebni dokument v Sloveniji, je nezadostna, socialno nepravična ter ni v skladu s podnebno znanostjo. Predvideva namreč le 36odstotno zmanjšanje izpustov do leta 2030, ob tem pa bi se pospešila še degradacija narave (npr. s spodbujanjem gradnje hidroelektrarn in izrabe biomase) ter povečali socialnoekonomska neenakost in brezposelnost.

Ali bomo del rešitve ali pa ostanemo del problema

Podnebnih sprememb ne moremo več ustaviti, lahko pa jih omejimo in se jim prilagodimo, a za to potrebujemo hitre, pametne in sistemske odzive. Za pripravo ukrepov je nujno poznavanje vzrokov sprememb, ki nam jih lahko odkrije le znanost. Koncept sonaravnega razvoja in zasledovanje cilja dostojnega življenja za vse znotraj naravnih omejitev planeta sta obvezi človeštva, saj lahko le tako uresničujemo skupne cilje družbe. Žal pa je varstvo okolja vse preveč zgolj mantra političnih in družbenih gibanj, ne pa prepoznana praksa. Pri tem radi pozabljamo, da je temelj vsega narava. Naravo moramo zaščititi, kjer je to še mogoče, oz. jo revitalizirati, kjer so za to danosti.

Predlagamo spoštovanje, upoštevanje in omogočanje neodvisnosti državnih inštitucij s področja varstva narave in okolja, katerih odločitve naj temeljijo izključno na strokovni presoji temelječi na znanstvenih izsledkih. Da bi obrnili trend uničevanja svojega bivanjskega prostora, potrebujemo novo vizijo razvoja družbe, ki mora vključevati celostno, družboslovno, humanistično in naravoslovno obravnavo okoljskih tematik. Te tematike morajo biti tudi del učnih načrtov na vseh ravneh izobraževanja.

Predlagamo ustanovitev posvetovalnega konzorcija, sestavljenega iz biologov in energetskih strokovnjakov, ki naj pripravi okoljsko vzdržno energetsko strategijo Slovenije, upoštevaje nizkoogljičnost, trajnost in okoljsko neoporečnost.

Ohranjanje biodiverzitete

Organizme moramo varovati v njihovih ekosistemih, vključno z zavarovanimi območji, in v nadomestnih okoljih. Za zagotovitev tega morajo biti izpolnjeni številni pogoji.

- Pri projektih upravljanja prostora in izkoriščanja naravnih virov mora vrednost biodiverzitete prevladati nad takojšnjimi gospodarskimi in družbenimi koristmi. Potrebujemo nacionalno strategijo spremljanja biodiverzitete in ukrepov za njeno varovanje ter predlagamo ustanovitev vladnega posvetovalnega organa (oz. konzorcija inštitucij) za reševanje biodiverzitetne krize. Za biodiverzitetno znanost in stroko potrebujemo posebne nacionalne sklade za financiranje raziskav in znanstveno podprtih ukrepov.
- Učinkovito upravljanje zavarovanih območij vključuje spremljanje stanja z vidika ohranjanja biodiverzitete (razvoj monitoringov, ki bodo nakazovali širše stanje biodiverzitete v ekositemih, vključujoč ključne vrste, združbe in ogrožene vrste), pa tudi spremljanje in usmerjanje obiska ter zagotavljanje predpisanih varstvenih režimov, kar pa ni izvedljivo brez ustreznega, dolgoročno stabilnega financiranja.
- V slovenskem morju in na morskem obrežju smo šele na pol poti opredelitve reprezentativne mreže zavarovanih območij, kakor tudi s stališča njihovega učinkovitega upravljanja. Skromni obseg ter majhno število morskih in obalnih zavarovanih območij nikakor ne predstavljajo zadostne protiuteži razvojnim trendom in negativnim vplivom vseh človekovih dejavnosti, vezanih na morski in obrežni prostor jadranskega bazena. Ključen izziv na politični ravni, povezan z upravljanjem slovenskega morja in morskega obrežja, je proaktivno sodelovanje v subregionalnih, regionalnih in globalnih procesih ter mehanizmih, kot so jadranskojonska komisija, Barcelonska konvencija in Konvencija o biološki raznovrstnosti.
- Zagotovljeno mora biti redno posodabljanje rdečih seznamov ogroženih vrst kot ključnega orodja za preprečevanje propadanja biodiverzitete.
- Nobenih ovir ni, da ne bi človeštvo s svojimi znanji preprečilo nadaljnjega izumiranja vrst in propadanja ekosistemov. Za učinkovito in gospodarno ohranjanje vrst in ekosistemov je ključno ustanavljanje rezervatov, trajnostno izkoriščenje naravnih virov z ozirom na biodiverziteto in biodiverzitetna genomika.
- Ker ni tehnološkega razloga, zaradi katerega bi morala neka vrsta izumreti, je skrajna možnost ohranjanja organizmov ohranjanje njihovih zamrznjenih tkiv in genetskih zasnov v zbirkah zamrznjencev – kriozbirkah. Za to pa potrebujemo nacionalno, medinštitucionalno zbirko dednega materiala vrst – nacionalno zbirko zamrznjencev in njeno vključitev v mednarodne sheme, kot je Global Genome Biodiversity Network.

Pitna voda je eno največjih naravnih bogastev Slovenije

Stanje voda v Sloveniji je bistveno slabše, kot se zdi iz oglasov o Sloveniji kot zeleni turistični destinaciji. Podatki monitoringov stanja voda, habitatov in vrst niso spodbudni. Skrajni čas je, da obrnemo trend. V času vse pogostejših pritiskov zaradi hitrega spreminjanja podnebja bo odpornost vodnih in priobalnih ekosistemov še posebno dragocena. Skupaj nam lahko uspe izboljšati ekološko stanje voda za dobrobit sedanje in prihodnjih generacij in predlagamo več ukrepov.

- Priprava celovitih in dolgoročnih načrtov upravljanja porečij, ki bodo zapolnili vrzel med premalo konkretiziranimi strateškimi načrti (PUN, NUV, NZPO, NUMO) in umestitvijo posameznih posegov ter drugih obremenitev v porečja prek prostorskega načrtovanja in gradnje. Porečni načrti bi dali podlago za optimizacijo ukrepov oziroma posegov na posameznih porečjih ali na morju.
- Zagotovitev platforme za sodelovanje deležnikov (strokovnjakov državnih in neodvisnih inštitucij s področja inženirskih strok, biologe in naravovarstvenike, kakor tudi prebivalce, ki živijo ob vodah, ter splošno javnost) pri pripravi načrtov. Iz več projektov celovitih posegov v porečjih, so znane odlične prakse sodelovanja vseh deležnikov ob reki.
- Ureditev področja nadzora in odgovornosti nad upravljanjem vodnih in priobalnih ekosistemov ter spremljanja učinkov ukrepov in posegov.
- Vodi je treba dati prostor, npr. prek odkupov zemljišč za odpiranje rek, meandre in obnovo obrežne ter poplavne vegetacije, saj s tem upočasnimo tok reke, omogočimo ponovno vzpostavitev neprekinjenega prenosa sedimentov ter povečamo območja širjenja poplav in s tem preprečujemo poplave urbanih površin.
- Pri obnovi ekološkega stanja rek uporabimo dobre prakse v EU, npr. v Franciji in tudi v Sloveniji. Tovrstni ukrepi kažejo odlične rezultate glede revitalizacije narave, hkrati pa zvišujejo kakovost življenja lokalnega prebivalstva in prinašajo koristi tudi za širšo družbo.
- Nadaljuje naj se vzpostavitev zaščitenih območij za najmanj 30 % morskih površin najkasneje do leta 2030.
- Zagotovi naj se stabilno financiranje za izvedbe revitalizacije, odstranjevanja ovir na vodnih telesih, vzpostavitev zaščitenih območij ter za upravljanje in nadzor.
- Predlagamo trajnostne, na znanstvenih spoznanjih in okoljskih danostih temelječe prakse v kmetijstvu, ki bi omogočale lokalno pridelavo večjih količin kakovostne in predvsem rastlinske hrane, s čim manjšo odvisnostjo od razpoložljive vode za

namakanje in brez čezmerne uporabe pesticidov ter drugih onesnaževal.
- Predlagamo vpeljavo rastlinskih sort, ki so bolje prilagojene na okoljske danosti v Sloveniji, upoštevajoč tudi spreminjajoče se podnebne razmere.

Naravi prijazno razogljičenje

- **Ukrepe za učinkovito rabo energije v industriji in gospodinjstvih ter njihovo izvajanje je treba postaviti na vrh prioritetnega seznama.** Ti ukrepi znižujejo ali vsaj upočasnjujejo rast porabe električne energije. Posledično zmanjšujejo potrebo po novih energetskih objektih, ki imajo na naravo pogosto zelo negativne učinke.
- Potencial sončnih elektrarn v Sloveniji ostaja v veliki meri neizkoriščen. Predlagamo, da se pospešeno usmeri k spodbujanju in umeščanju malih in velikih sončnih elektrarn tja, kjer vpliva na naravo ni oz. je zanemarljiv. Pripravi naj se strokovna karta izključitvenih območij, kjer postavitev večjih sončnih elektrarn zaradi varovanja narave ni mogoča. Kot splošno načelo naj se gospodinjstva, skupnosti, občine, industrijo in večje investitorje z različnimi ukrepi usmerja k postavitvi manjših sončnih elektrarn na strehe, večje pa tam, kjer njihovo umeščanje ne bo poslabšalo stanja v naravi (npr. degradirana območja, vzdolž avtocest, sobivanje s kmetijskimi dejavnostmi). Pri sončni tranziciji naj imajo pomembno vlogo tudi energetske zadruge, kjer se lokalne skupnosti ali prebivalci bloka povežejo in skupno investirajo v sončno oz. vetrno elektrarno. Ker imajo skupnosti od tega finančne in druge koristi, se posledično olajša umeščanje objektov v prostor, poveča podpora takšnim projektom in pospeši razogljičenje elektroenergetskega sektorja.
- Približno dve tretjini s strani osnutka Nacionalnega energetskega programa identificiranega potenciala vetrnih elektrarn v Sloveniji sta z vidika varovanja ptic povsem sprejemljivi. Obstajajo tudi območja, podrobneje določena v znanstveni študiji *Karta občutljivih območij za ptice za umeščanja vetrnih elektrarn v Sloveniji*, ki so zaradi varovanja ptic za gradnjo vetrnih elektrarn nesprejemljiva. Predlagamo, da se *Karta* znanstveno in strokovno posodobi s stališča varovanja celotne biotske pestrosti, določi izključitvena območja in investitorje usmeri na sprejemljive lokacije. Študijo, s katero se določijo te lokacije, razumemo kot konstruktiven, strokoven in tehten pristop k sočasnemu varovanju narave ter procesu razogljičenja elektroenergetike. Odločevalcem predlagamo, da tudi za ostale nizkoogljične elektrarne, predvsem sončne izdelajo oz. naročijo podobno študijo, ki naj usmerja umeščanje elektrarn. Tako se bo okrepil proces uporabe tistih nizkoogljičnih virov energije, katerih potencial je v Sloveniji danes slabo izkoriščen in ima dokazano manjše negativne vplive na naravo. Tak način delovanja bo zmanjšal nepotrebne konflikte in pospešil proces razogljičenja.
- Nuklearne elektrarne imajo, upoštevajoč njihov življenjski cikel, v primerjavi z drugimi vrstami elektrarn na proizvedeno enoto električne energije enega najmanjših vplivov na naravo in okolje. Ker pa se po drugi strani spopadajo s posebnimi izzivi, naj o sprejemljivosti potencialne gradnje novega bloka jedrske elektrarne steče široka javna razprava, utemeljena na predstavitvi naravoslovnih in družboslovnih strokovnih stališč.
- Na energetskem področju predlagamo pospešen razvoj in hitrejše uvajanje sodobnih tehnologij (npr. baterij) in pristopov (npr. aktivni odjem), večje vlaganje v ter povezovanje različnih sektorjev (npr. mobilnost, sektor toplote, elektroenergetika). To lahko prispeva k nemotenemu delovanju vedno kompleksnejšega elektroenergetskega sistema, k učinkovitemu vključevanju spremenljivih virov energije in novih porabnikov v sistem ter k manjši potrebi po novih konvencionalnih energetskih objektih s pogosto bistvenim vplivom na naravo. Ob tem je treba razvoj in uvajanje sodobnih tehnologij in pristopov ter povezovanje sektorjev izvajati sistemsko s preseganjem partikularnih interesov ter s širšo sliko v mislih, zato naj se daje pri usmerjanju razvoja večja vloga strokovnim in javnim inštitucijam.

Pripravili organizatorji simpozija V vrtincu sprememb: povezanost vode, življenja in podnebja z Nacionalnega inštituta za biologijo in gibanja Mladi za podnebno pravičnost na osnovi prispevkov in razprav, dosegljivih na povezavah: https://www.youtube.com/watch?v=pXLEK109P7s in https://www.youtube.com/watch?v=8BrVV6N4smQ.

Marina Dermastia (Nacionalni inštitut za biologijo, NIB), Tina Eleršek (NIB), Jadranka Jezeršek (Kontekst svetovanje), Lučka Kajfež Bogataj (Biotehniška fakulteta, Univerza v Ljubljani), Matjaž Kuntner (NIB), Tamara Lah Turnšek (NIB), Matjaž Ličer (Agencija Republike Slovenije za okolje in NIB), Lovrenc Lipej (NIB), Miha Mikelj (Mladi za podnebno pravičnost, MZPP), Izidor Ostan Ožbolt (MZPP), Maja Ravnikar (NIB), Katja Sinur (NIB), Darja Stanič (NIB), Timotej Turk Dermastia (NIB), Al Vrezec (NIB)

Poljudna priredba Okoljskega manifesta: **Marjan Žiberna**

IN MEMORIAM

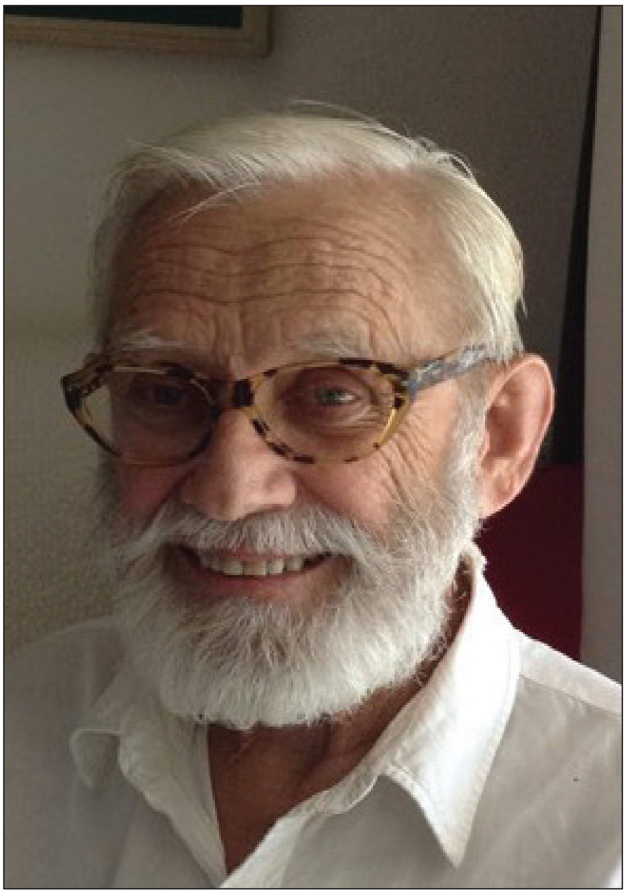
IN MEMORIAM

PROF. DR. JOŽE ŠTIRN
(1934 - 2021)

Konec avgusta se je poslovil bivši predstojnik Morske biološke postaje Nacionalnega inštituta za biologijo (MBP NIB) kolega prof. dr. Jože Štirn, upokojeni znanstveni svetnik na Nacionalnem inštitutu za biologijo in upokojeni redni profesor na Univerzi v Ljubljani. Rodil se je leta 1934 v Ljubljani. Po končani gimnaziji leta 1946 je študiral biologijo na Univerzi v Ljubljani in diplomiral 1965. Še pred diplomo je ustanovil Center za podvodna raziskovanja (1962) in organiziral odmevno odpravo v Rdeče morje in Etiopijo. Center je nato prerastel v Zavod za raziskovanje morja v Portorožu, kjer je prof. Štirn izvajal obsežno raziskovanje pelagiala severnega Jadrana s temeljnimi oceanografskimi in kemijskimi meritvami, predvsem pa analizami fitoplanktona. S te tematike je tudi leta 1968 doktoriral na ljubljanski univerzi in naslednje leto izdal pri SAZU odmevno disertacijo v knjižni obliki z naslovom "Pelagial severnega Jadrana". Delo, v katerem je med prvimi opozoril na vpliv dotoka hranil s Pada, ostaja eden izmed temeljev oceanografskega znanja o severnem Jadranu. Po letu 1968 je vodil Oddelek za bentoške nevretenčarje ameriškega Inštituta Smithsonian v Salamboju v Tuniziji.

Leta 1970 se je vrnil v domovino in prevzel vodenje Morske biološke postaje Inštituta za biologijo Univerze v Ljubljani v Portorožu. S praktičnimi izkušnjami iz biološke oceanografije ter z bogatimi mednarodnimi zvezami je podprl začetne korake novoustanovljene postaje in njene mlade raziskovalne skupine. Začel je z obsežnim raziskovalnim projektom, ki je vključeval raziskave bioloških, fizikalnih in kemijskih lastnosti obalnega morja vključno s pritoki, morskega rastlinstva in živalstva ter morskih združb in onesnaženja so bile osrednje teme razsiskav. Lokalna ribja industrija (Delamaris) je podprla raziskave populacijske dinamike in ekologije malih pelaških rib, predvsem sardele in inčuna, pa tudi možnosti gojenja školjk. Ker so zaprta in obalna morja, kakršno je tudi Jadransko in še posebej severni Jadran, med najbolj ogroženimi, se je raziskovalna skupina pod vodstvom prof. Štirna usmerila v raziskave onesnaženja morja z različnimi onesnaževali, med katerimi so izstopale težke kovine (z Institutom Jožef Stefan, Kemijskim inštitutom) in pesticidi (s Kmetijskim inštitutom).

Podobno kot v mnogih obalnih območjih so se tudi v severnem Jadranu pokazale posledice prekomernega vnosa hranil s pogostimi cvetenji fitoplanktona, velikimi masami nekaterih pridnenih alg in pomanjkanjem kisika v slojih na dnu morja. Raziskovalna skupina si je kmalu pridobila ugledno mesto v sredozemskem prostoru, zlasti z inovativnimi raziskavami antropogeno pogojene evtrofikacije. Izvirno zasnovan dveletni kontrolirani poskus odvajanja komunalnih odplak v zgrajeni bazen v Strunjanski laguni je nazorno prikazal posledice vnosa nečiščenih komunalnih odplak v obalnem ekosistemu, ki smo jih sicer lahko desetletja spremljali v notranjosti Koprskega zaliva. Na osnovi teh izsledkov je prof. Štirn formuliral smernice za odvajanje komunalnih odplak na Obali, ki so temeljile na ustreznih čistilnih napravah in daljših podvodnih izpustih v morje, in so danes vidne v Piranu. V istem času je prof. Štirn v okviru MBP zasnoval uspešno mednarodno poletno šolo z uglednimi domačimi in tujimi predavatelji, ki ji je Medvladna oceanografska komisija Organizacije Združenih narodov za izobraževanje, znanost in kulturo (Intergovernmental Oceanographic Commission of United Nations Educational, Scientific and Cultural Organization – IOC-UNESCO) podelila status regionalnega izobraževalnega centra za temeljno in aplikativno ekologijo. Kot izredni in nato redni profesor je v sedemdesetih



Prof. dr. Jože Štirn

in osemdesetih letih prejšnjega stoletja poučeval oceanografijo, ekologijo morja in ribiško biologijo na Oddelku za biologijo Biotehniške fakultete Univerze v Ljubljani in bil mentor več diplomantom, magistrantom in doktorantom.

Za razvoj MBP je bila zelo pomembna vzpostavitev regionalnega programa za Sredozemsko morje (Sredozemski akcijski načrt, Mediterranean Action Plan – MAP) v okviru Programa Združenih narodov za okolje (United Nations Environment Programme – UNEP) leta 1975, v katerem MBP sodeluje še danes. Na osnovi njegovih odmevnih znanstvenih objav iz tistega obdobja sta mu UNEP in FAO pri OZN poverila pripravo projekta raziskovanj ekoloških vplivov morskega onesnaževanja v Sredozemlju s sedežem v Alžiru. Vse to je bistveno prispevalo k trajajočemu sodelovanju Morske biološke postaje v mediteranskih projektih teh organizacij, financiranju raziskovalne opreme in štipendiranju sodelavcev MBP v tujini. Prof. Štirnu s sodelevci je kasneje uspelo pridobiti nove prostore za postajo ulici Fornače v Piranu in jih preurediti v sodoben morski raziskovalni center. S tem je prof. Štirn zaslužen ne le za razvoj Morske biološke postaje, temveč tudi za mednarodni ugled ustanove, ki danes deluje kot organizacijska enota Nacionalnega inštituta za biologijo.

V začetku osemdesetih let je prof. Štirn odšel v tujino. Zaposlil se je pri Medvladni komisiji za oceanografijo pri UNESCO z večletnimi misijami v Jemnu, Adenu in v Kamerunu. Med letoma 1988 in 1990 je bil profesor na Univerzi v Nici. Nato je prevzel odprto profesuro na Univerzi Sultan Qaboos v Omanu ter poučeval biološko oceanografijo in ekologijo morja.

Kot svetovalec je načrtoval in upravljal tamkajšnji nacionalni program ribištva in sodeloval na ekspedicijah v Indijskem oceanu in Perzijskem zalivu. Raziskoval je oceanografske razmere, bioprodukcijo in združbe morskih organizmov ter zbral množico planktonskih vzorcev in v sklopu projekta Tethys, ki ga je vodil, pripravljal monografijo in atlas planktonskih alg Sredozemskega morja, Indijskega oceana in obrobnih morij. Po njem so poimenovali nov rod rdečih alg *Stirnia prolifera* in sedem živalskih vrst. Vrsto let je predaval na Université Internationale de la Mer v Cagnes-sur-mer, ki mu je leta 2002 podelila naziv zaslužnega profesorja. Še v pokoju je v letih 2005-2009 vodil projekt o vplivih delovanja Luke Koper na onesnaževanje Koprskega zaliva. Od leta 1992 je bil dopisni član Evropske akademije za okolje v Tübingenu. Leta 1973 je prejel Nagrado Sklada B. Kidriča, leta 2012 pa Veliko nagrado Nacionalnega inštituta za biologijo za življenjsko delo.

Prof. Štirn je bil naravoslovec širokih pogledov, pa potapljač, limnolog, oceanograf, predvsem pa morski fitoplanktolog in ekolog. Že zgodaj je spoznal nujnost povezave ekologije morja z oceanografijo ter kemijo in mikrobiologijo morja. Njegova znanstvena zapuščina obsega predvsem izsledke o biološki oceanografiji pelagiala in ribiški biologiji male plave ribe v severnem Jadranu ter marikulture, predvsem pa o odvajanju in vplivih odpadnih vod na obalno morje in s tem povezano evtrofikacijo. Tako je postavil temelje za kasnejše bolj specializirano raziskovalno delo v posameznih segmentih ekologije morja na Morski biološki postaji. S številnimi prispevki v poljudno-znanstvenih revijah in dnevnem časopisju je pomembno prispeval k osveščanju javnosti o onesnaževanju morja, opozarjal pa je tudi na njegovo bogastvo in možnost izkoriščanja. Njegovi prispevki so navdušili številne kasnejše strokovnjake s področja morskih ved na Morski biološki postaji in drugod.

Jadran Faganeli

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KAZALO K SLIKAM NA OVITKU

SLIKA NA NASLOVNICI: V Sredozemskem morju se je letos prvič pojavil morski pes kitovec (*Rhyncodon typus*). Opazili so ga na jugovzhodni turški obali v bližini Sirije. Gre za največjo vrsto morskega psa, ki se prehranjuje z zooplanktonom. (Foto: B. Furlan)

Sl. 1: Pajkoliko mačje uho *Ophrys argolica* subsp. *crabronica* je ena izmed najlepših sredozemskih vrst mačjih ušes. Obenem je endemična vrsta kukavičevk, ki jo najdemo v osrednji in južni Italiji. (Foto: A. Pezzetta)

Sl. 2: Rumeno mačje uho *Ophrys lutea* subsp. *lutea* je značilna sredozemska vrsta kukavičevk, ki jo najdemo v južnoevropskih državah. (Foto: A. Pezzetta)

Sl. 3: Skorjasta vrsta polža gološkrgarja *Knoutsodonta pictoni* je bila odkrita in opisana šele pred nekaj leti. Zato se o tej vrsti, ki se prehranjuje z mahovnjaki, še vedno ve zelo malo, kaže pa, da je v Tržaškem zalivu pogostejša, kot smo doslej mislili. (Foto: M. Fantin)

Sl. 4: Mačje uho vrste *Ophrys promontori* je endemična kukavičevka, ki raste le v območju Monte Gargana in nekaterih drugih južnih predelih Apeninskega polotoka. (Foto: A. Pezzetta)

Sl. 5: Muholiko mačje uho *Ophrys insectifera* podobno kot druge vrste teh kukavičevk pritegne opraševalce z obliko, ki zelo dobro oponaša videz njihovih samic. (Foto: A. Pezzetta)

Sl. 6: Sredozemsko morje se v zadnjih desetletjih sooča s prihodi raznih vrst iz Rdečega morja in Atlantika. Med slednjimi se je pred kratkim pojavila tudi barvita vrsta polža gološkrgarja *Okenia picoensis*, ki so jo odkrili in opisali na otoku Pico v azorskem arhipelagu v Atlantiku. (Foto: A. Lombardo).

INDEX TO IMAGES ON THE COVER

FRONT COVER: This year saw the first appearance of the whale shark (*Rhyncodon typus*) in the Mediterranean. The specimen was spotted on the southeastern Turkish coast near Syria. This is the largest species of shark that feeds on zooplankton. (Photo: B. Furlan)

Fig. 1: *Ophrys argolica* subsp. *crabronica* is one of the most beautiful Mediterranean orchid species of the genus Ophrys. At the same time, it is an endemic species found only in central and southern Italy. (Photo: A. Pezzetta)

Fig. 2: The yellow ophrys *Ophrys lutea* subsp. *lutea* is a typical Mediterranean species of orchid found in southern European countries. (Photo: A. Pezzetta)

Fig. 3: The encrusting nudibranch *Knutsodonta pictoni* was discovered and described only a few years ago. Therefore, very little is known about this species that feeds on bryozoans, but apparently it is more common in the Gulf of Trieste than previously thought. (Photo: M. Fantin)

Fig. 4: The promontory orchid *Ophrys promontori* is an endemic species found only in the area of Monte Gargano and some other southern parts of the Apennine Peninsula. (Photo: A. Pezzetta)

Fig. 5: The fly orchid *Ophrys insectifera*, like other species of the genus *Ophrys*, attracts pollinators with its shape that mimics that of pollinator females very well. (Photo: A. Pezzetta)

Fig. 6: Over the recent decades, the Mediterranean Sea has witnessed arrivals of various species from the Red Sea and the Atlantic. Among the latter, a colourful species of sea slug, the nudibranch *Okenia picoensis*, has recently emerged and was discovered and described from the island of Pico of the Azores archipelago in the Atlantic. (Photo: A. Lombardo).

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